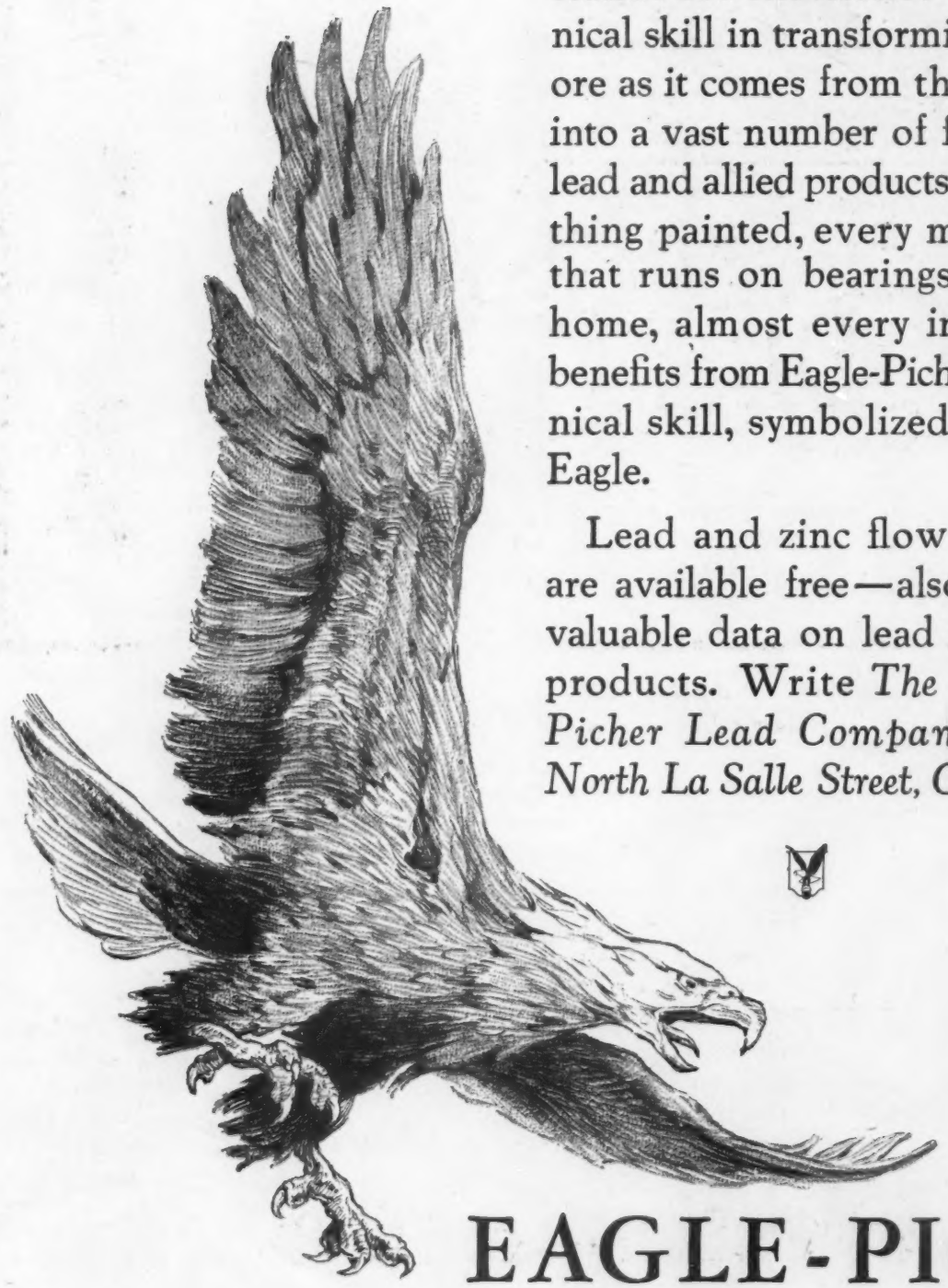
THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

DEC 17 192 LIBRARY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
VOL. VIII, NO. 6 NOVEMBER, 1927

Follow the Eagle



THE eagle—long the symbol of majesty and power—stands for excellence of technical skill in transforming lead ore as it comes from the mines into a vast number of finished lead and allied products. Everything painted, every machine that runs on bearings, every home, almost every industry benefits from Eagle-Picher technical skill, symbolized by the Eagle.

Lead and zinc flow sheets are available free—also other valuable data on lead and its products. Write *The Eagle-Picher Lead Company, 134 North La Salle Street, Chicago.*

EAGLE-PICHER

Producers of Lead, Zinc and Allied Products

C. D. SMITH,
Sales Engineer
Georgia Tech. '18

F. L. KOUCKY,
Salesman
North Dakota, '12

M. S. HANCOCK,
Motor Engineer
Illinois, '17

H. W. WILLIAMS,
Control Engineer
Cornell, '18

YOUNGER COLLEGE MEN
ON RECENT WESTINGHOUSE JOBS

W. F. EAMES,
Control Engineer
Carnegie Tech. '18

D. SANTINI,
Control Engineer
Ohio State, '23

C. M. PURDY,
Contract Administration
Westinghouse Tech. '26

G. W. HUNTER,
Contract Administration
Westinghouse Tech. '27

The World's Largest Hotel

Great achievements in engineering are brought about by the harmonious work of many. The individual's largest opportunity comes through the exercise of his own creative talents in the field for which he is preëminently prepared.

* * *

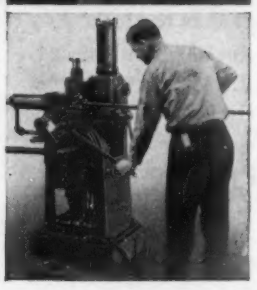
THE larger a hotel, the larger loom the difficulties of ventilating it; of handling the crowds that ride its elevators. The larger, too, looms the interest of engineers in designing electrical equipment to meet such unprecedented demands, of salesmen in selling it, of service engineers in installing it and keeping it in top-notch operating condition.

To Westinghouse came the Hotel Stevens for ventilating motors, for its elevator system, for the electrical equipment of its laundry. To Westinghouse come many undertakings of such kind and size—a steady stream of imagination-stirring opportunities to do the never-before-accomplished. All of tremendous interest to college men who have ambition, resourcefulness, capacity; disciplined sales and engineering minds.

* * *

The Hotel Stevens contains 3,000 rooms and baths. The Variable Voltage Control System used in the elevators was designed by Westinghouse. Whether you rise ten floors or only one, there are no jerks or jars. Speed is the same whether the car is empty or whether it's packed. Cars automatically stop level with the floor—no "jockeying"—no "step up," or "step down, please."

Westinghouse



"Speed Up with Air"

The road builder, the street department, and the public service company have a new slogan,

"Speed Up with Air"

Modern portable air compressors and handy hammer drills, concrete breakers, clay spaders, portable hoists, speed up road grading, street repairs, rock or clay trenching, to a rate of accomplishment undreamt of only a few years ago. Labor costs are cut in two, improvements are finished earlier, interest losses on waiting capital are reduced, public good will is fostered.

Sullivan Portable Compressors and Sullivan compressed air tools are widely known and used in this construction field. They embody a generation of experience in the design and use of compressed air equipment for the miner, quarryman and contractor. They are marketed by 22 Sullivan branch offices, assisted by leading dealers in more than 50 cities.

Sullivan equipment is built and sold by engineers, graduates of colleges like yours. In this work, engineering knowledge and ability find full play, and are well rewarded.

A booklet, "Engineering Opportunities with the Sullivan Machinery Company" will be sent free upon request

Catalogues on Sullivan Air Compressors and equipment are yours for the asking

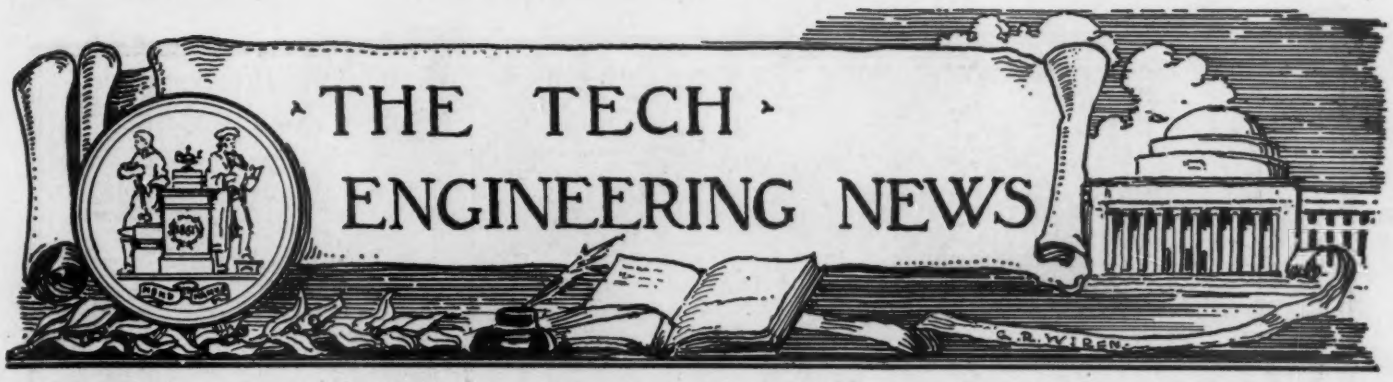
COMPRESSORS · AIR LIFT · COAL CUTTERS · DIAMOND CORE DRILLS · ROCK DRILLS
PORTABLE HOISTS · DRILL SHARPENERS AND FURNACES · BUSTERS · SPADERS

SULLIVAN TRADE MARK MACHINERY COMPANY

NEW YORK LONDON PARIS TOKYO SYDNEY

164 SOUTH MICHIGAN AVENUE, CHICAGO

OFFICES IN ALL PRINCIPAL CITIES



Volume VIII | CAMBRIDGE, MASS., NOVEMBER, 1927 | Number 6

Copyright 1927 by The Tech Engineering News

Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.
Published monthly throughout the school year by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergraduates.

THE MANAGING BOARD

ADAM K. STRICKER, JR. '29, *Editor*
JOHN S. MIDDLETON, '28, *General Manager*
JOHN A. CARVALHO '28, *Business Manager*
HOWARD S. GARDNER, JR. '30, *Associate Editor*
THOMAS H. SPELLER '29, *Managing Editor*
WILLIAM BAUMRUCKER '29, *Advertising Manager*
EVERETT P. WEATHERLY JR. '29, *Circulation Manager*
GEORGE J. MEYERS, JR. '29, *Publicity Manager*

EDITORIAL DEPARTMENT

THE EDITORIAL BOARD

HOWARD A. ROBINSON, '30, News Editor

EDITORIAL STAFF

B. K. COUPER '29
M. R. BOYER '29
C. F. EDLUND '30
N. H. BALL '29

BUSINESS DEPARTMENT

THE BUSINESS BOARD

CHARLES C. LADD '30, Assistant Circulation Manager
ANTHONY R. SAVINA '30, Assistant Circulation Manager

BUSINESS STAFF

C. J. CUSTER '29
L. S. THORSEN '30
A. A. HORNE '30
G. P. WALKER '29
J. P. BOGGS '30
B. C. BUERK '30
W. W. WEDEMEYER '30

THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman, Prof. Leslie F. Van Hagan, Madison, Wisconsin

The Transit
Iowa Engineer
Colorado Engineer
Nebraska Blue Print
Pennsylvania Triangle
Sibley Journal of Engineering
Purdue Engineering Review
Rose Technic
Michigan Technic
Ohio State Engineer
Minnesota Techno-Log
The Tech Engineering News
University of Virginia Journal of Engineering
Wisconsin Engineer
Penn State Engineer
Technograph
Cornell Civil Engineer
Kansas State Engineer
Kansas Engineer
Princeton E. A. News Letter
Armour Engineer

SUBSCRIPTION PER YEAR, $1.50

Address all communications to The Tech Engineering News, Walker Memorial, Cambridge 39, Massachusetts. Telephone, University 6864
Advertising rates upon application

TABLE OF CONTENTS

Page

WHY JOIN A PROFESSIONAL SOCIETY? By Dugald C. Jackson 253
THE DETERMINATION OF CONCRETE SPECIFICATIONS.
By Dean Peabody Jr., '10 254
RESEARCH ON INDUSTRIAL ILLUMINATION. By C. E. Snow, '23 257
NICKEL CAST IRON. By A. E. Hanson and E. J. Bothwell 258
TURBINES OF HIGHER CAPACITY. By H. Loring Wirt, '18 260
AGRICULTURAL ENGINEERING. By Thomas D. Campbell 263
EDITORIALS 265

10%

The power construction work of Stone & Webster is 3,120,000 horse power—10% of the installed capacity of the industry.

Steam power work, 2,060,000 h. p.
Water power work, 1,060,000 h. p.

STONE & WEBSTER
INCORPORATED

DESIGN · BUILD
OPERATE
FINANCE

BOSTON, 49 Federal Street
NEW YORK, 120 Broadway
CHICAGO, First National Bank Bldg.
SAN FRANCISCO, Holbrook Bldg.
PITTSBURGH, Union Trust Bldg.
PHILADELPHIA, Real Estate Trust Bldg.

©Cl B758953 C R

NOV 25'21

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VIII NOVEMBER, 1927 NUMBER 6

Why Join a Professional Society?

Some interesting sidelights on the professional societies and the opportunities they offer the student and graduate engineer

By DUGALD C. JACKSON

Head of the
Department of Electrical Engineering
Massachusetts Institute of Technology

WHY does one join a professional society? For the satisfaction derived from the associations, for the pleasure of acquaintances made and some warm friendships derived as a result of the contacts at meetings and through correspondence, for the joy of debate with one's equals or one's betters at meetings. These are all causes that have pleasure and great value for young men and continued pleasurable satisfaction for the older ones. A prideful possession and prompt reading of the best writings in one's field also leads to a wish to have the society publications promptly and at first hand, which is the pleasure and privilege of a member. A reason less sentimentally compelling in our individualistic country is the favorable influence on one's standing which arises from officially ranging oneself alongside of professional and scientific fellows; but this may be considered as a reasonable duty. Lord Bacon long ago observed (in discussing his Maxims of the Law) that "I hold every man a debtor to his profession; from the which as men, of course, do seek to receive countenance and profit, so ought they of duty to endeavor themselves by way of amends to be a help and ornament thereto." Were he living today, I have no doubt that Lord Bacon would repeat this maxim of his. From this aspect, one should not be content to always remain in the junior ranks of membership, but should request transfer to the more established grades as age and accomplishment provide eligibility.

In matters of personal and professional association, such as are here under consideration, one takes out of a situation in proportion to what he puts in; but paradoxically one seems to receive more than he gives when trying in reasonable measure to give more than he receives. It therefore does not suffice for a young man to just "join." If he wishes to enjoy and also profit from the advantages of a professional society, he must take part in the affairs of the society. This means some discussion of papers orally or by letter, writing of papers, attending some meetings and taking part in the Section government. This attracts friends. It also, when done with some wisdom, provides experience of unfailing serviceability. The phrase "with some wisdom" refers not only to the manner of doing, but also to carrying on without interfering with one's duty to one's employer.

Membership in professional societies costs money for annual dues, and attendance on a convention once in a while also involves cost even if normal expenses are paid by one's employer. For the young engineer who is ambitious to progress in reputation, responsibility and pay, these expenses are items for serious thought, especially after he has married. The wife may not see any concrete influence on the future to come from the expenditure of either money or time. Needed new shoes of a prettier style for the baby and some time to make minor repairs to household equipment are concrete and present needs. I know, for I have been through it. When I was a cub engineer my wife called me a "joiner" (I was an Associate Member of American Institute of Electrical Engineers before being married, but joined other societies later); but we agreed together then and still agree that the time, effort and money expended for the societies has been fruitfully, indeed prolifically, recompensed by the desirable associations, friendships and business relations which have been an outcome. This personal point is put in for encouragement, not as an example. I would not say to any young man, "go thou and do likewise." Each young man must reason out his career for himself. But with respect to the professional societies, the young man who com-

(*Continued on page 276*)

We take great pleasure in publishing Professor Jackson's comments on the professional societies, as heis in a better position to appreciate their value than most of the engineers of today. Professor Jackson has been actively connected with the American Institute of Electrical Engineers and the American Society of Civil Engineers for some time. He served as president of the American Institute of Electrical Engineers several years ago, and is now vice-chairman of the National Research Council. He has found it worth the time, money, and effort to take part in the affairs of the society, and it would be well for us to see if we could not get some of the advantages from affiliation with the society in our chosen branch of the profession.

The Determination of Concrete Specifications

An analysis of the factors influencing the economical design of concrete mixtures

By DEAN PEABODY, JR., '10
Assistant Professor Applied Mechanics
Massachusetts Institute of Technology

A CONCRETE mixer is often seen near the wayside gorging itself with hurriedly piled wheelbarrow loads of stone and sand, a few bags of cement and with water somewhat lavishly supplied by the genie in charge. Such a procedure turns out concrete of a sort which probably sticks together, but whose strength may vary forty per cent above or below the strength desired. In either case someone loses money. If the concrete gives a compressive strength of 2500 pounds per square inch when 2000 pounds per square inch is required, the contractor has probably used more cement than is necessary, and cement costs money. On the other hand, if the concrete tests 1500 pounds per square inch, the owner of the structure does not get his money's worth and the load may not be carried satisfactorily.

The contractor and engineer, from the early days of the use of concrete, have endeavored to determine some simple field method of proportioning the amounts of cement, sand, stone and water so that the desired strength could be obtained.

It was soon realized that the cement must be chosen with great care as it was the costly strength-giving element, the glue that held the inert rock particles together. A series of tests for Portland cements standardized by the American Society for Testing Materials enables the engineer to be certain that his cement has strength, will set well, and will not crack or disintegrate after it is in place.

It took longer for the engineer to recognize that the sand and stone could seriously affect the strength. Even today worthless concrete must be laboriously removed whose sole fault is that the sand contained loam or other organic matter. At times gravel may be supplied which is coated with a dried slimy film so that the cement glue cannot get a grip. Sometimes the stone or sand particles may be rotten rock, or flat slaty flakes or weak sandstone. Since the cement glue merely transfers the load from sand grain to stone particle, both grain and particle must be strong enough to carry these loads. A visual examination will identify the type of stone and its cleanliness, also the composition of the sand, but the cleanliness of the sand cannot be guaranteed by a glance. The harmful qualities are found in the finest portion. The presence of organic matter can be shown by shaking in a bottle a sand sample with a 3 per cent solution of sodium hydroxide (NaOH) and allowing it to stand for 24 hours. At that time the color of the liquid (tannic acid) covering the sand indicates the relative purity. If it is a clear or straw color the sand is clean. Dark yellow means some organic matter is present, while the orange and red browns are cause for rejection. There are also wash tests for the quantity of clay and silt. It is possible, then, to determine that the aggregate (sand and stone) is probably free from harmful material. The only infallible test, however, is to mix concrete and thus know its strength.

TABLE I

TYPICAL SIEVE ANALYSES OF AGGREGATE

Size of Sieve	Per Cent Coarser than Each Sieve Sand	Screenings	Stone	Pebbles
1½	0	0	0	0
¾	0	0	40	15
⅜	0	0	100	45
4	20	0	100	100
8	35	25	100	100
16	55	35	100	100
30	70	75	100	100
50	90	80	100	100
100	100	85	100	100
Fineness Modulus	3.70	3.00	7.40	6.60
Range in Size	0-⅜ in.	0-4	⅜-1½	4-1*

*1 and 2-inch sieves are used in determining size of aggregate but are not used in calculating fineness modulus.

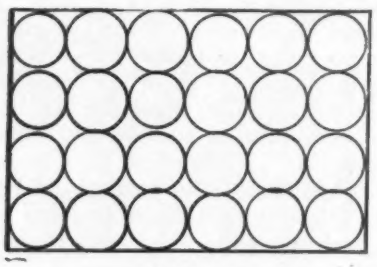


FIG. 1

In concrete using gravel alone, voids between the spherical pebbles must be filled with cement.

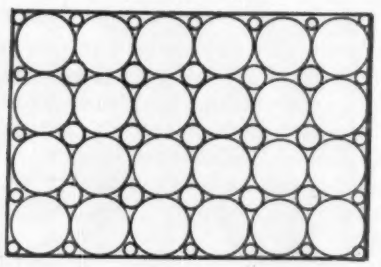


FIG. 2

Ideal view showing how these voids may be partially filled by the use of sand.

An aggregate may be clean and yet not produce a high strength concrete. The problem is to glue up a stone wall cheaply with cement. The surface areas to be glued and the holes between stones to be filled with cement fix the amount of cement to be used. For instance, if an aggregate is composed of spherical particles of the same diameter (Fig. 1) the surface areas to be wet with the cement-glue can be computed and also the volume of the voids between spheres. If smaller spheres are placed in the voids (Fig. 2) the total volume of cement used is reduced and at the same time a stouter stone wall is produced. In practice aggregates are not spheres and the finer particles do not always fall into the proper hole. Nevertheless, aggregates with particles of varying size give higher strength than one-size aggregates. Relative sizes can be studied by sieving the material and plotting the per cent held on a sieve against the area of the sieve opening. In the past such studies have given desirable grading curves for aggregates with the least voids. The best grading is given by a material which is predominately coarse with medium and fine particles to fill the voids.

In many localities good aggregates are not plentiful and many are used which are known to be poorly graded. The relative worth of any material can be expressed as a fineness number

TABLE II

CLASSES OF CONCRETE FOR DIFFERENT DEGREES OF EXPOSURE

Class of Concrete (Expected Strength at 28 days lb. per sq. in.)	Maximum Quantity* Mixing Water U.S. gal. per sack of cement (94 lb.)	Type of Structure or Degree of Exposure
3000	6	Roadways, piles, pressure pipe and tanks. Thin structural members in severe exposure. Walls, dams, piers, etc., where exposed to severe action of water and frost.
2500	6¾	Sewers, bridges, walls, dams, piers, etc., for all weather conditions and moderate action of water and frost.
2000	7½	Ordinary enclosed reinforced concrete buildings. Bridges and retaining walls of heavy sections in moderate exposure.
1500	8¼	Mass concrete, basement walls, etc., protected from water or severe weather conditions.

*Free water or moisture carried by the aggregates must be included as part of mixing water.

(or fineness modulus), determined by sieving the aggregate through the 9 standard sieves (see Fig. 6, next page.)

TABLE A

Sieve Mesh	Opening (side of square) Inches
One Hundred	0.0059
Fifty	0.0118
Thirty	0.0236
Sixteen	0.047
Eight	0.094
Four	0.188
Three-eighths	0.375
Three-fourths	0.75
One and a half	1.50

Each opening is four times the area of the next smaller area. The sum of the total percentages held in each sieve divided by 100 gives the fineness modulus.

From Table I it is evident that coarsely graded material has a high modulus, while fine sand has a low number. The variation of compressive strength of concretes made in the ratio of one volume of cement to five volumes of aggregate is shown by Fig. 4. As aggregates of higher fineness modulus are used a greater compressive strength results. It will also be noted that the maximum strength is given by a concrete which has so little sand that it cannot be placed easily and a honeycombed concrete would result when used in large masses commercially.

The greatest abuse in concrete proportioning occurs in the measuring of the water to be used. Too dry a mix can be remedied by adding water and re-mixing. Too wet a mix is hopeless. The excess water cannot be removed without taking out some cement. A wet mix pours quickly for hasty, careless work. It is always a temptation to the laborer to manufacture sloppy concrete.

An excess of water directly affects the strength and water-tightness of concrete. The chemical action of setting requires a definite amount of water. The wetting of the surfaces, plus the water absorbed, requires an additional volume. Any water added beyond these two amounts remains as water in the setting concrete or escapes through the forms or to the surface carrying cement with it. The water in the mass as the concrete dries evaporates, leaving a hole, and the compressive strength of holes is not great. The cement carried off by the water is wasted, while some of that carried to the surface forms a frothy mass of "laitance" of low strength and poor bonding qualities for the next layer to rest upon.

The investigations of the Portland Cement Association have established a relation between the compressive strength of concrete and the water-cement ratio, or ratio of volume of water to volume of cement (Fig. 5). This relation assumes, of course, workable mixes of the same consistency. While apparently concentrating on the quantities of water and cement the relation involves also the grading of the aggregate and its volume. For instance,

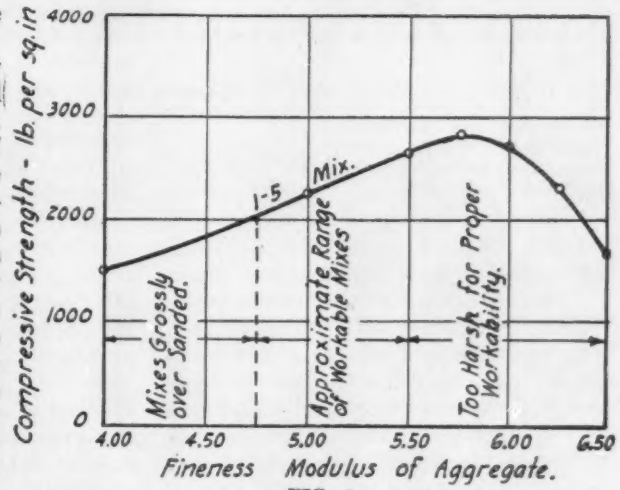


FIG. 4

Effect of grading of aggregate on the compressive strength of concrete

Curve A, Fig. 5, calls for a water-cement ratio of 0.8 to produce a concrete whose compressive strength is 3000 pounds per square inch. This may be given by a fine aggregate using a rich mix with much water and cement, or the strength may be given using a well-graded aggregate which requires little water and cement to glue it to-

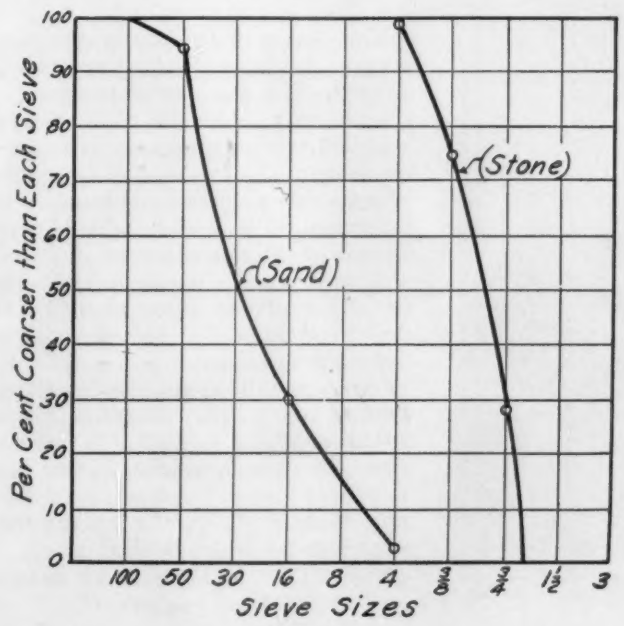


FIG. 3

Sieve analysis curves

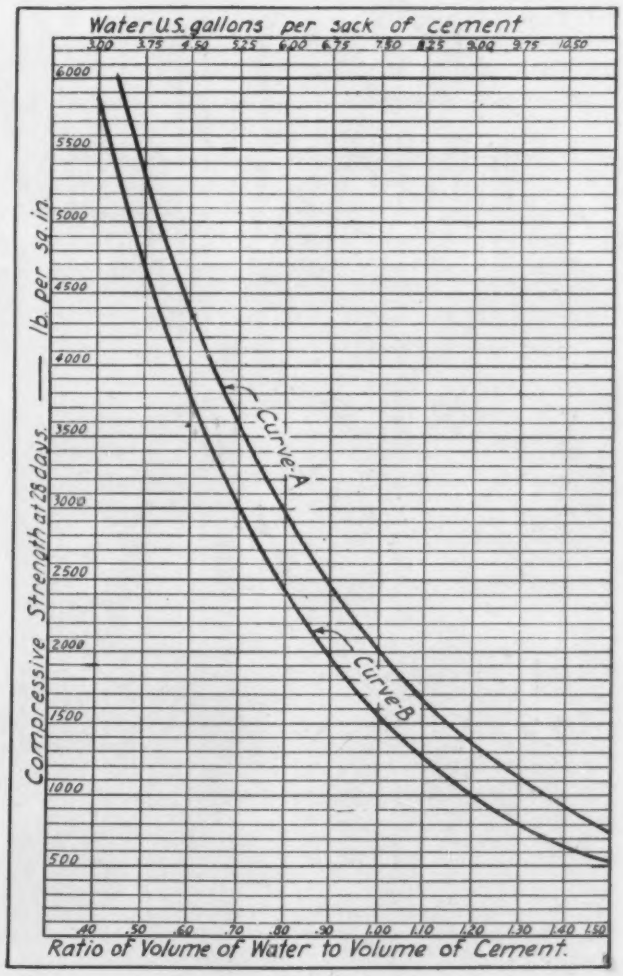


FIG. 5

Curve A shows effect of quantity of mixing water on the strength of concrete where the water-cement ratio can be accurately controlled. Curve B shows effect where only approximate data is available.

TABLE III

RECOMMENDED SLUMPS FOR CONCRETE

Type of Structure	Slump — inches Minimum	Maximum
Massive sections, pavements and floors laid on the ground	1	4
Heavy walls, slabs, beams...	3	7
Thin walls, columns, etc.....	4	8

gether. Table II gives the desirable strengths for most construction work.

The consistency of the mix is determined by the use of a "slump" test. The concrete is rammed into a truncated cone mold. Grasping both handles, the mold is carefully removed and the inches of slump of the concrete mass are recorded. Wet mixes will spread out giving a small final height.

It has been the custom in the past to express the proportions of a concrete mix as the ratio of the volumes of ingredients. Thus a 1:2:4 mix is composed of one volume of cement, 2 volumes of sand, and 4 volumes of stone. The method of measuring the sand, and to a less extent the stone, will affect the amount of sand or stone particles actually included in a volume. Damp sand "bulks" due to the moisture surrounding the particles. The density is also affected as the sand is measured loosely, shaken, or rammed into the container. The standard method of measurement is a rammed dry sample because shaken or loose measurements are difficult to duplicate.

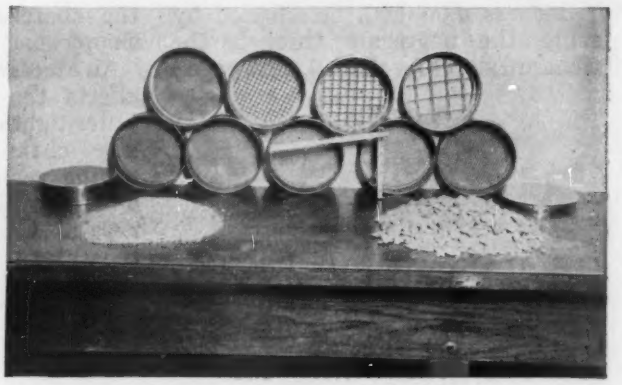


FIG. 6
Standard set of sieves

Sand and stone mixed together give a final volume less than the sum of the separate parts. A small addition of sand would disappear in the voids between the stone, and the resulting volume be equal to that of the original stone. As more sand is used some of it separates the stone particles and the resultant volume exceeds the original amount of stone. For usual mixes the final volume is about 80 to 90 per cent of the sum of the sand and stone volumes.

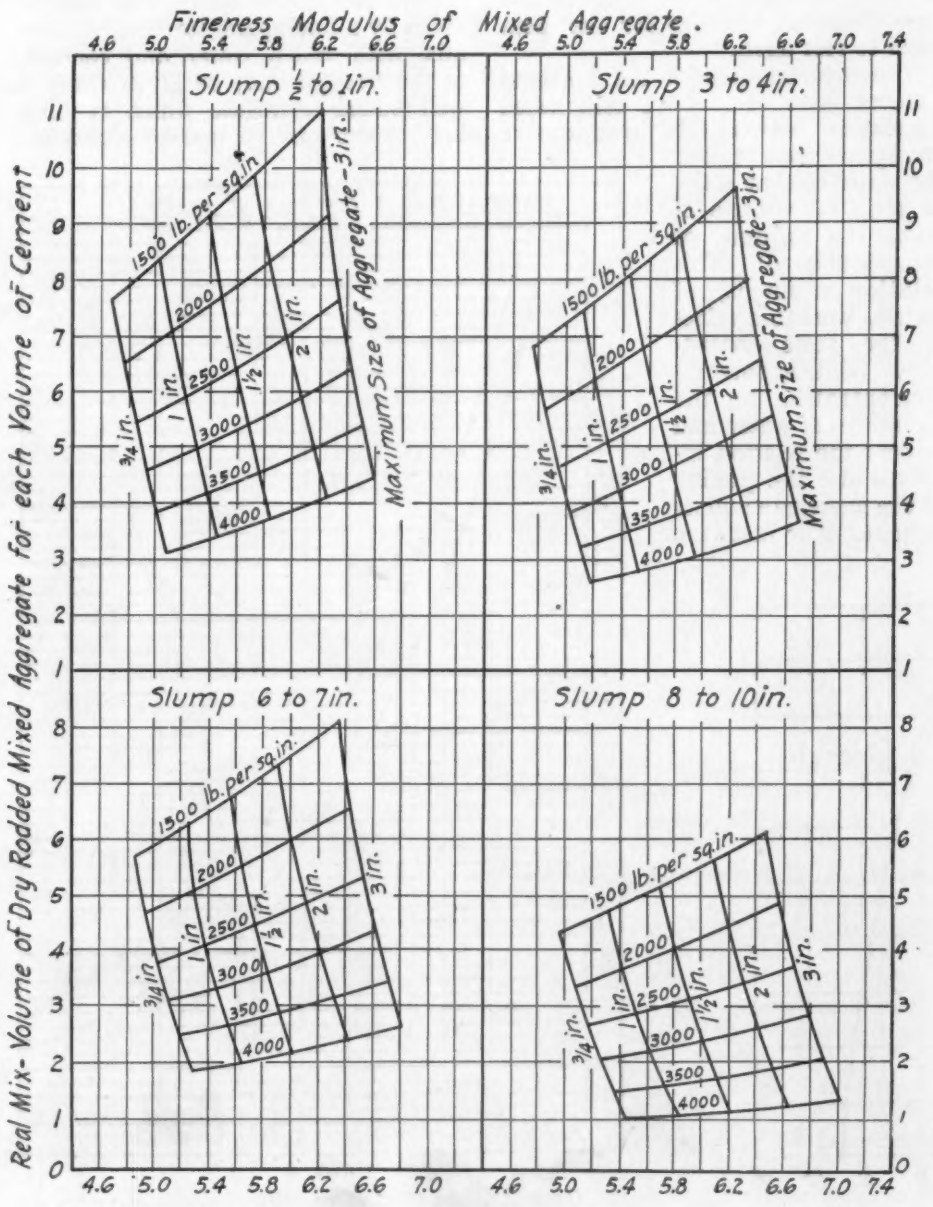


FIG. 7
Fineness modulus mixed aggregate based on Curve A, Fig. 5

The proportions of a mix by the fineness modulus method are expressed in terms of the ratio of the volume of cement* to the volume of rammed dry mixed aggregate. This "real mix" can be supplied by a damp mixed gravel measured loosely or by separate sand and stone aggregates whose ratios are adjusted so that measured loosely they will combine to give the correct rammed mixed aggregate.

TABLE IV

RECOMMENDED PROPORTIONS OF AGGREGATES

Maximum size of coarse aggregate Inches	Ratio of coarse to fine on basis of dry compact volumes Minimum	Maximum
⅜	0.40	0.80
¾	0.60	1.50
1 and over	1.00	2.00

The design of the mix starts with a knowledge of the strength and wetness desired. The designer of the structure specifies the strength that must be equalled. The engineer or superintendent on the job should decide from his experience what consistency of mix is necessary to handle the concrete. Thus a plant consisting of an elevator and push carts pouring a slab might use drier mixes than a plant that deposited concrete by chuting into deep narrow walls.

The strength and consistency being known, a strength curve for this consistency similar to Fig. 5 is consulted and the water-cement ratio determined. This ratio should be used for a mix that contains the maximum of aggregate possible; in other words, the cheapest mix is that which uses the

(Continued on page 276)

*One 94 pound sack of cement is assumed to be one cubic foot volume.

Research on Industrial Illumination

A discussion of the relation of illumination intensity to productive efficiency

By C. E. Snow,* '23
Instructor Electrical Engineering Department, Massachusetts Institute of Technology

IT is the purpose of this article to give a general description of a series of tests of the effect of illumination intensity on production conducted under the supervision of the committee on industrial illumination of the division of engineering and research of the National Research Council. The phases of the tests toward which attention will be directed are the methods of test procedure, the industrial operations investigated, a statement of results, and a statement and analysis of some of the problems which arise in such an investigation.

The late Dr. Ernest Fox Nichols, president of the Massachusetts Institute of Technology in 1921, and chairman of the committee on research of the Illuminating Engineering Society in 1924, was in a large measure the instigator of this illumination study. He contributed a large part of his valuable time in organizing a tentative program for such an important undertaking, and with the approval of President Stratton, persuaded Professor Jackson of the Massachusetts Institute of Technology, to accept the active chairmanship of a committee on industrial illumination. This committee represents the division of engineering and research of the National Research Council and is part of a large directive board composed of most distinguished men. These men include well-known executives, electrical engineers, illuminating engineers, educators, psychologists, ophthalmologists and an official of the American Federation of Labor. This committee in handling such an investigation, was practically ideal in that it represented a completely impartial but highly interested and informed body of men. Mr. Thomas Edison accepted the honorary chairmanship of the directive board and in the spring of 1924, the first meeting was held in the library-room of his laboratory at West Orange, N. J., to discuss and pass upon the policy and program of the investigation. The phases covered in this investigation included an exhaustive review of the literature, and a series of laboratory tests and industrial illumination-production tests carried out in the factories. This paper will be confined to a consideration of the industrial tests. The classes of work chosen for investigation are representative, with respect to their eye task, of the most common types in industry. The Institute of Technology was selected as the central organization to carry on the tests and the Illuminating Engineering Society gave its endorsement and adherence to the plan.

The first industrial test was conducted in the switch assembly department of a large eastern manufacturing plant and covered a period of six months. A group of operatives to be included in the test were selected and means taken to record the average hourly production of the group. The first part of the test constituted a period during which the operatives worked under the original lighting installation and gave a production rate which was used as the base, or arbitrary standard, for any future changes in production efficiency caused by the introduction of a higher illumination intensity. The level of artificial illumination intensity furnished by the original installation was 7 foot-candles. This intensity was raised to 9 and then to 23 foot-candles for periods lasting 5 to 6 weeks. Throughout the test the artificial illumination was supplemented by so much daylight that any average based on these intensities is of little value. It will be observed that the original level of intensity of artificial illumination (7 foot-candles) was well above factory lighting characteristic of the United States, and this was also aided by natural lighting.

This article by Mr. Snow is of especial interest to all those connected with Technology, as it is the first published information on this important research. It is of interest to note that the investigation is being financed by the National Research Council. This is an indication of the close connection between the Council and the Institute. The investigation is typical of that carried on in many other departments and should cause us to appreciate and make use of the opportunities here offered us.

In each case of increased illumination intensity there was an appreciable increase in the production rate. However, when the artificial intensity was changed to that of the two lower levels, the production rate remained at its new high level.

This test brought to mind clearly the important effect of uncontrolled

(*Continued on page 272*)

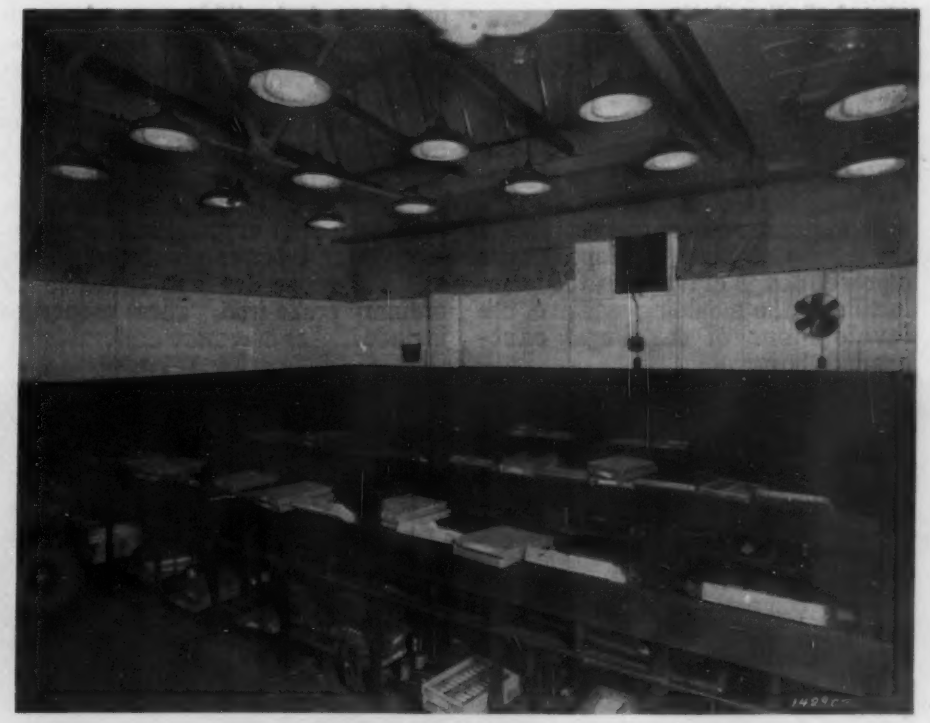


FIG. 1. REGULATED ILLUMINATION

The intensity of illumination in this test room was accurately controlled by means of artificial lighting

*Heretofore, research assistant in the research described.

Nickel Cast Iron

A description of the properties of this new alloy, with reference to its economical use as an engineering material

By A. E. Hanson and
E. J. Bothwell
International Nickel Company

THE history of cast iron during the last quarter of a century affords a most illuminating example of the inevitable effect of laissez-faire when applied to scientific research. While other materials have been developed by the combined efforts of many workers both in industry and in independent laboratories, up to five years ago very little had been done to improve the basic properties of cast iron, with the result that this old material has been largely supplanted by other products. The true position of the industry is not revealed by the statistical records. A detailed examination would show that forgings, stampings, pressings, die-castings and cheap steel have made great inroads into the cast iron fields.

The substitution of cast iron by newer forms appears to have been regarded as inevitable, in spite of the fact that only a moderate increase in the general level of the physical properties was necessary to ensure its continued use in many instances. Moreover, the low cost of cast iron left sufficient margin for a moderate increase in price. That so little should have been done is remarkable when one considers the manifold advantages of cast iron and the obvious possibilities of research as suggested by the development of alloy steels.

The continued production of large tonnage has, until recently, been due solely to a steady bettering of foundry practice which has permitted the adoption of mass production methods. Centrifugal cast iron pipes are replacing many lines of corroded mild-steel pipes, and many other new uses for cast iron have also been developed. The improved design of furnaces, the introduction of the moulding machine, the development of centrifugal castings and the use of permanent moulds have helped to maintain the tonnage output of the foundries at a point sufficiently high to permit operating in the face of keen competition from other materials. But none of these improvements touched the really crucial point, which was to secure higher physical properties in the basic material.

Cast iron possesses properties that make it a very desirable material for many uses. The readiness with which it may be cast into intricate shapes and its ability to fill out very thin sections together with its low cost, make it ideally suited for countless applications. In appreciation of these facts, research work was instigated to improve the properties of cast iron to a point where it could regain the markets that had been lost. This research work began about four years ago and the effects of nickel and chromium as alloying elements were investigated.

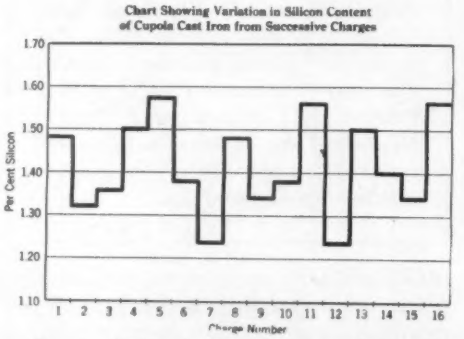


Fig. 1. Although silicon improves the machinability of irregular castings the percentage of it in successive furnace charges is hard to maintain.

Since the object of this research was definitely commercial, it will be interesting to examine the nature of the properties required. High efficiency units, such as Diesel engines, railway locomotives and power plant equipment, call for properties not available in ordinary grade iron. These properties include higher and more uniform hardness, improved structure, grain refinement, better machinability, freedom from internal shrinkage, greater resistance to wear and increased toughness and strength. More briefly, dependable castings are required, and users are willing to pay a reasonable price to secure them, provided these properties are guaranteed.

Plain cast iron contains varying percentages of carbon, silicon, manganese, sulphur and phosphorous, and the properties of the metal depend largely upon the correct adjustment of these percentages, particularly those of carbon and silicon.

The rate of cooling of the casting is also a very important factor. When molten cast iron is poured into a sand mould, the rapid absorption of heat by the sand results in a chilling of the outer surface of the casting and the consequent production of a hard, white skin on heavy castings and completely chilled edges and corners in the lighter sections.

Chill is a well-known phenomenon in gray iron castings. Its cause and effect are thoroughly understood. Owing to the rapid absorption of heat from the surface of the metal, the temperature at which the carbon is precipitated as graphite is not maintained long enough to permit the production of a gray material. The result is that the iron near the skin of the casting contains most of its carbon in solution and a white, unmachinable product is the result. While this effect is most noticeable on the surface of the iron, there is an area directly beneath the white skin where a lesser degree of chill may also be noted by the persistence of an excess of free carbides or white iron. These carbides, or "hard spots," decrease from surface to center, the depth they penetrate depending upon the rate at which the casting is cooled. The result is that various conditions obtain in different parts of the same casting, even though the iron be poured from the same ladle. This condition, it will therefore be seen, is directly related to the condition of the carbon. It has long been realized

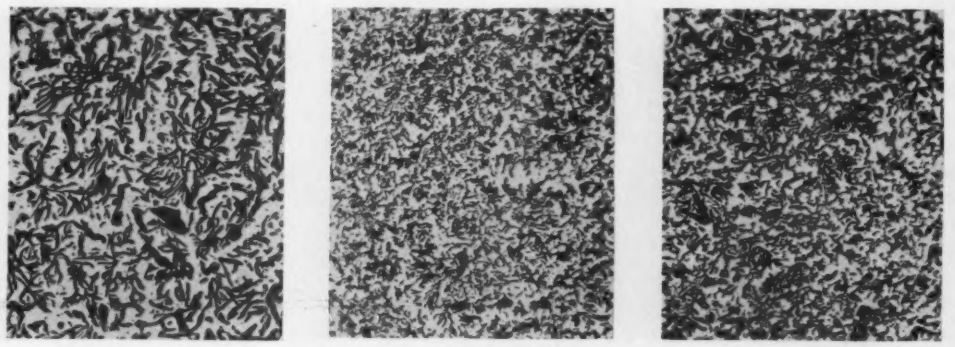


Fig. 2. Effect of nickel in refining grain of gray iron arbitration bars of Cupola iron (3.45% carbon, 1.0% silicon, Magnification .30%)

that once the uniform distribution of the combined carbon could be controlled, a great advance would be made in the metallurgy of cast iron.

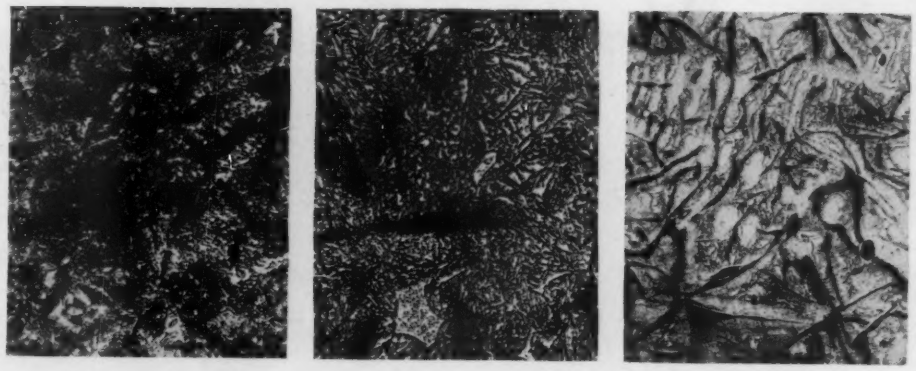
The steps ordinarily taken to reduce combined carbon, *i.e.*, keep total carbon and silicon high, manganese and sulphur low, and cool slowly, are precisely those which promote graphitization. The balancing of these various factors, however, is sometimes a difficult matter. With a regular shaped casting the problem is simplified. But many castings have to be made with both heavy and light sections. A mixture which will produce a satisfactory amount of combined carbon in a given section may not do so in sections which are either lighter or heavier. This situation can be partially met in plain cast iron by using several mixtures, but when the same casting contains both light and heavy sections, recourse to this practice is impossible. Since a low silicon iron is best adapted to a heavy section and a high silicon iron to a light section, a compromise would result in too soft a mixture for the former, which would accordingly show internal shrink, while hard edges would be produced in the latter and the iron would be difficult to machine.

The obvious method of solving such a problem is to find some element capable of controlling the combined carbon, so that it will not be so susceptible to cooling conditions, or, in other words, to the size of sections. Research work has shown nickel to be such an element.

In ordinary practice, as has been previously stated, silicon is used to eliminate chill from the lighter section. The effect of this element, however, is to cause internal shrinkage and open texture in the heavier sections, so that while the use of silicon does accomplish a single purpose, the value of the improvement is more than offset by the attendant disadvantages. Moreover, as shown in figure 1, it is also quite difficult to maintain a constant silicon content in cupola iron. For this reason, unless a wide margin of safety is provided, it is not practicable to depend on this element to insure a machinable product.

The use of nickel permits the employment of mixtures having a low enough silicon content to minimize the danger of internal shrink. This is explained by the fact that the nickel functions similarly to silicon in its action on the carbon. It has been determined experimentally and proven in practice that the relative efficiency of nickel to silicon as a graphitizing agent, is about 1 to 2. On this basis a mixture may be calculated having the required low silicon content and sufficient nickel to insure machinability in the light sections.

The action of nickel in precipitating carbon is unique. Before explaining this further some consideration should be given to the form in which this constituent is found in ordinary cast iron. If a piece of gray iron be examined microscopically it will be found that the graphite is present in three distinctly different forms. Large, sinuous flakes are found to predominate with an interspersion of smaller, finer flakes and occasionally a few nodular deposits (see figure 2a). The large flakes, known as primary graphite, are probably precipitated during the latter stages of solidification while the secondary or finer form occurs at lower temperatures below the eutectic temperature. The last mentioned is generally conceded to be a product of the decomposition of the iron carbide which has been thrown out of solution below the solidification range. Rapid cooling through the lower temperature range will operate to maintain the carbides as such whereas by abnormally slow cooling they may be entirely decomposed into their components ferrite and graphite.



SORBITE	MARTENSITE	AUSTENITE
Brinell hardens 241	302	112
Nickel 3.92%	8.62%	19.38%
Carbon 3.15%	2.72%	2.54%
Silicon 1.20%	1.60%	1.23%

FIG. 3. The microstructure of sorbite, martensite, and austenite in nickel cast iron (X500)

Considering the physical characteristics of the two forms of graphite, it will be seen that the smaller flakes, providing less continuous planes of weakness, are conducive to higher strength. On this basis it may therefore be assumed that a material containing graphite in the form of fine flakes has a greater strength than one in which the constituent is present in the large flaky condition.

While it has been stated that nickel and silicon act similarly on the carbon, a very important difference should be here pointed out. If the photomicrographs in Fig. 2b and 2c are examined it will be observed that nickel has apparently inhibited the formation of the typical primary graphite. The finely divided form, uniformly distributed, predominates in the nickel-bearing composition. Within limits, increasing the nickel progressively diminishes the size of these flakes. It is interesting to note that if sufficient nickel is present it is not possible to retain cementite (prevent the precipitation of carbon) even by rapid cooling through and below the range in which this constituent is formed. This is demonstrated by the failure to produce a chill in cast iron of this composition by casting it against a chill block in the manner employed in the production of chilled iron.

The hardness of gray cast iron containing nickel may be considered as proportional to the amount of alloy present. As the nickel content is increased up to 8–10 per cent (in moderate sections), there is a corresponding constitutional transformation. The maximum hardness is obtained when a complete Martensitic condition exists. Further additions of the alloy produce an Austenitic iron with a consequent reduction of hardness. This is illustrated in figures 3 and 4. It will be seen, from the photomicrographs and the preceding statements,

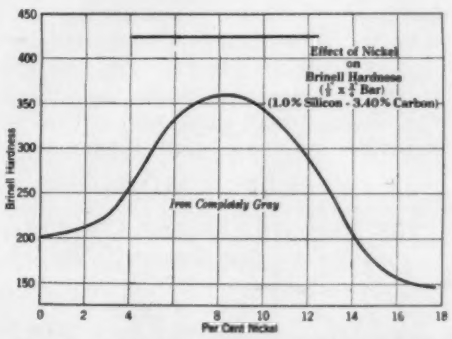
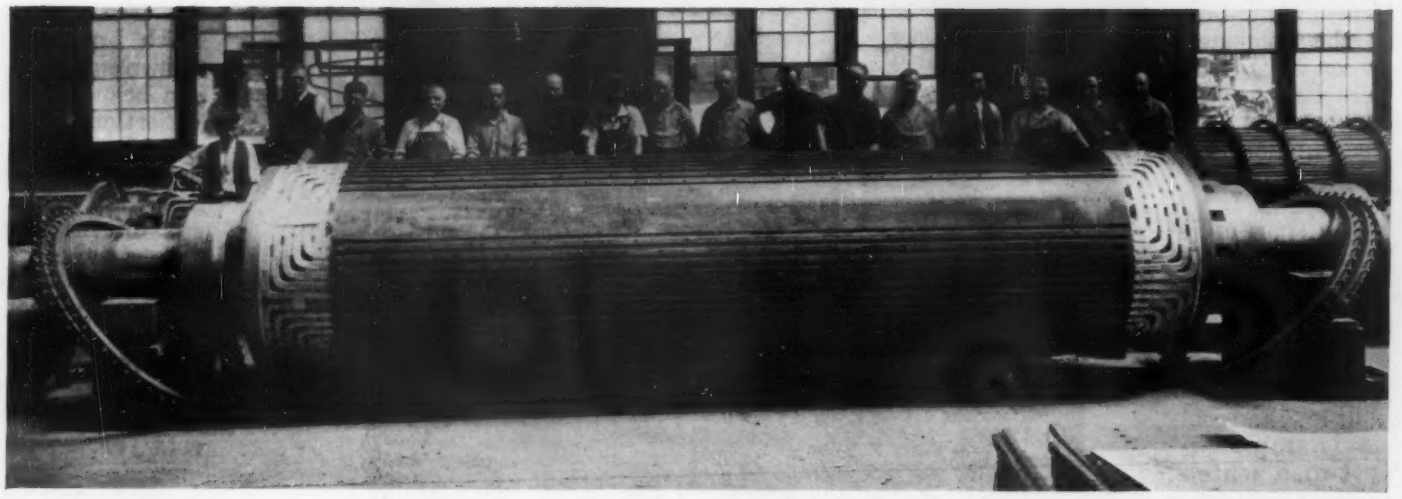


FIG. 4. With the addition of nickel to cast iron, the Brinell hardness reaches a maximum with 8% nickel.

(*Continued on page 278*)



THE ROTOR OF A LARGE GENERATOR

Turbines of Higher Capacity

A review of the development of the large turbo-generator with a description of some of the newer installations

By H. Loring Wirt, '18
Turbine Department, General Electric Co.

TURBINE sizes have developed so rapidly in the last few years that it is interesting to consider for a moment the heights actually reached. A turbine really begins to exist as soon as it is sold, for to meet delivery, work must start immediately on limiting features. Therefore, in order to make this summary of modern machines include the very latest developments, turbines that are on order will be discussed as well as those that are in service.

It is misleading, as well as almost impossible, to select the machine to designate as the world's largest turbine. Different units are large and noteworthy in different ways and the total kilowatt rating of a combination of compounded units is not necessarily a measure of the engineering achievement.

THE WORLD'S LARGEST TURBINES
On Order or Built November 7, 1927

What is Large	*How Large*	*Operating Company*
Largest Total kw Rating	208,000 KW	State Line Gen. Co.
Largest Single Cyl. Turbine	75,000 KW	Buffalo G. E. Co.
Largest Tandem Compound Turbine	160,000 KW	N. Y. Edison Co.
Largest Triple Compound Turbine	208,000 KW	State Line Gen. Co.
Largest Turbine Now Running	91,500* KW	Commonwealth Ed. Co. (Chicago)
Largest 1200 lb. Turbine	10,000 KW	Edison Elec. Illg. Co. (Boston)
Largest Mercury Turbine	10,000 KW	Hartford Elec. Lt. Co.
Largest 1800 rpm Generator	94,117 †KVA	United Elec. & Pow. Co., (Hell Gate-New York)
Largest 1800 rpm Now Running	75,000 KVA	Edison Elec. Illg. Co.
Largest 1500 rpm Generator	160,000 KVA	N. Y. Edison Co.
Highest Generator Voltage	22,000 V	State Line Gen. Co.

*This unit on September 27 carried under overload conditions 103,000 kw, which is the largest output the world has ever known from one unit.
†On order with the Westinghouse Electric and Manufacturing Co.

Above is a summary of the different ways in which different turbines are largest. In order to realize the recent rapid development in turbine sizes one should bear in mind that the size of a turbine is limited by the size of the generator and that ten years ago it was felt that the largest possible 1800 rpm generator would have a rating of 30,000 kw and 1200 rpm generators — 45,000 kilowatts.

The table below shows a tremendous increase in capacity over what was dreamed possible a few years ago and this increase has been made possible through engineering research, through the development and application of superior materials, and through the foresight and courage of the Central Station Industry which had the faith to back its judgment and the ability to develop the ever increasing use of electricity. A 208,000 kw unit would have been impossible to build a few years ago.

Along with the research and development work which has made possible the design and construction of these large units, attention is called to the phenomenal economies made in the consumption of coal per kilowatt delivered. Twenty years ago, two pounds of coal generated 1 kilowatt. Today there are a number of stations that produce a kilowatt with less than 1 pound of coal.

Under ideal conditions the minimum turbine heat rate twenty years ago was about 18,400 BTU's per kw hour and now some stations are under 11,000 BTU's.

This reduction in the heat rate chargeable to the turbines has, of course, been accompanied by improved efficiency in other power house apparatus and by improved methods of operation. The use of units of larger capacity has also tended to hold down the capital charge per unit of installed capacity, although the largest turbine units today cost 50 per cent more per unit of capacity than in the pre-war period and in spite of increased costs for fuel, for labor, for material and all other equipment, the price changes for electricity as a commodity have been

slightly downward in the face of greatly increased prices for almost all other commodities.

During this period cast iron has been replaced by steel in turbine shells; brass or bronze by steel, monel, and stainless iron in turbine blades; heat proof insulating material has been developed and countless changes have been made in details and methods of manufacture.

These points can best be illustrated by examples drawn from actual practice. A 208,000 kw turbine generator being built for the State Line Generating Co. in the Chicago district is an excellent example of a modern high efficiency unit.

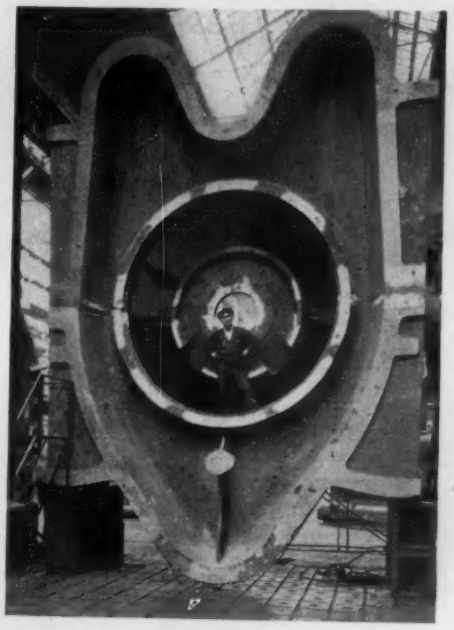
The turbine will operate under steam conditions of 600 pounds per square inch gauge pressure with 730° F. at the throttle. The steam while passing from the high pressure to the two low pressure cylinders will be reheated by live high pressure steam brought directly from the boiler and condensed in special heat interchangers close to the turbine. This raises the temperature of the working steam to the low pressure elements to 500° F. or a superheat of 165° F.

The three elements will operate at 1800 rpm. The high pressure turbine will drive a 76,000 kw, 85 per cent power factor main generator, and each double flow low pressure turbine will drive a 62,000 kw 85 per cent power factor main generator and a 4,000 kw service generator.

The main generators are to be wound for 22,000 volts, which is much higher than the voltage for which generators for commercial services have heretofore been designed. Each main and service generator will have its own direct connected exciter.

There are four vertical condensers on each side of the low pressure elements. The exhaust hoods are carefully designed so as to recover part of the loss due to the leaving velocity from the last stage wheels.

The high pressure turbine will run with either or both of the low pressure turbines. This will permit taking one of the low pressure turbines out of



SECTION OF SHELL
OF 94,000 KW TURBINE

service for cleaning condensers, etc., the other low pressure unit remaining in service delivering power.

The largest 1800 rpm on order is being built by the Westinghouse Electric and Manufacturing Company for the Hell Gate Power Station of the United Electric Light and Power Company at New York. Each element of a 165,000 kw cross compound turbine will drive an 1800 rpm main generator with a rating of 80,000 kw, 85 per cent pf or 94,117 kva, producing 3 phase, 60 cycle current at 13,800 volts. An auxiliary generator rated at 5000 kw, 80 per cent pf, producing 3 phase, 60 cycle current at 2400 volts will also be furnished.

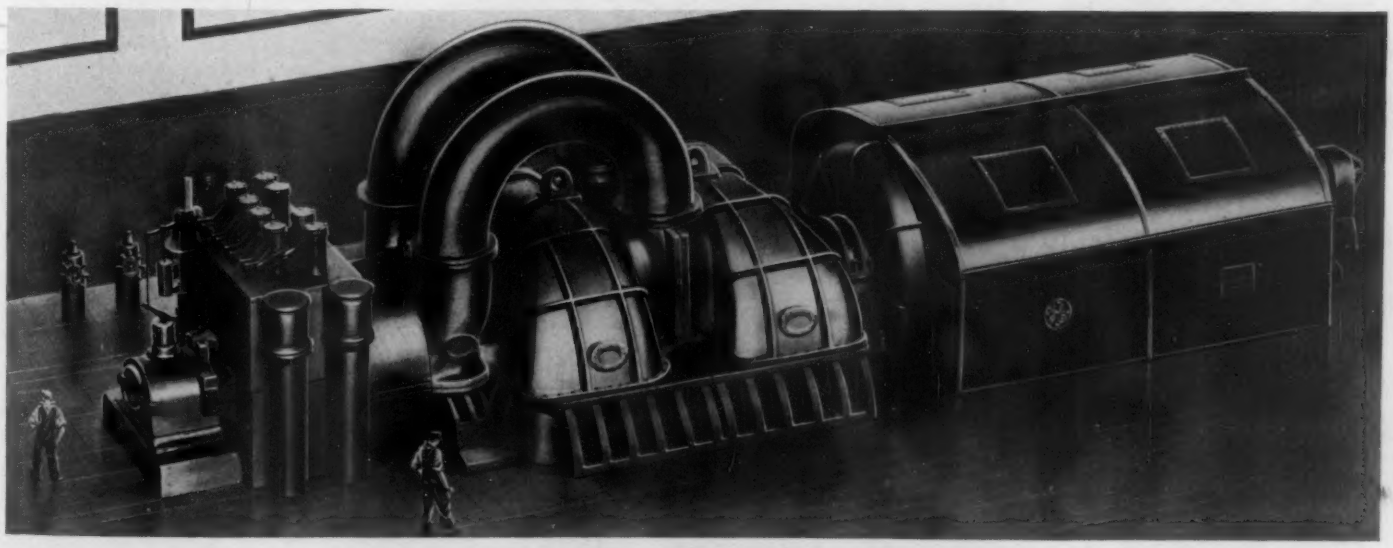
The largest 1800 rpm generator now running is in the Edgar Station of the Edison Electric Illuminating Company of Boston. It is rated 60,000 kw, 80 per cent pf or a total of 89,411 kva.

The 160,000 kw turbine which has recently been ordered for the East River Station of the New York Edison Company is illustrated below. This turbine will be the largest tandem compound (or single shaft) unit in the world. The turbine is of the tandem compound type with double flow in the low pressure element. As a result of outstanding developments in generator design and construction it is possible to connect this turbine to the largest single generator yet contemplated.

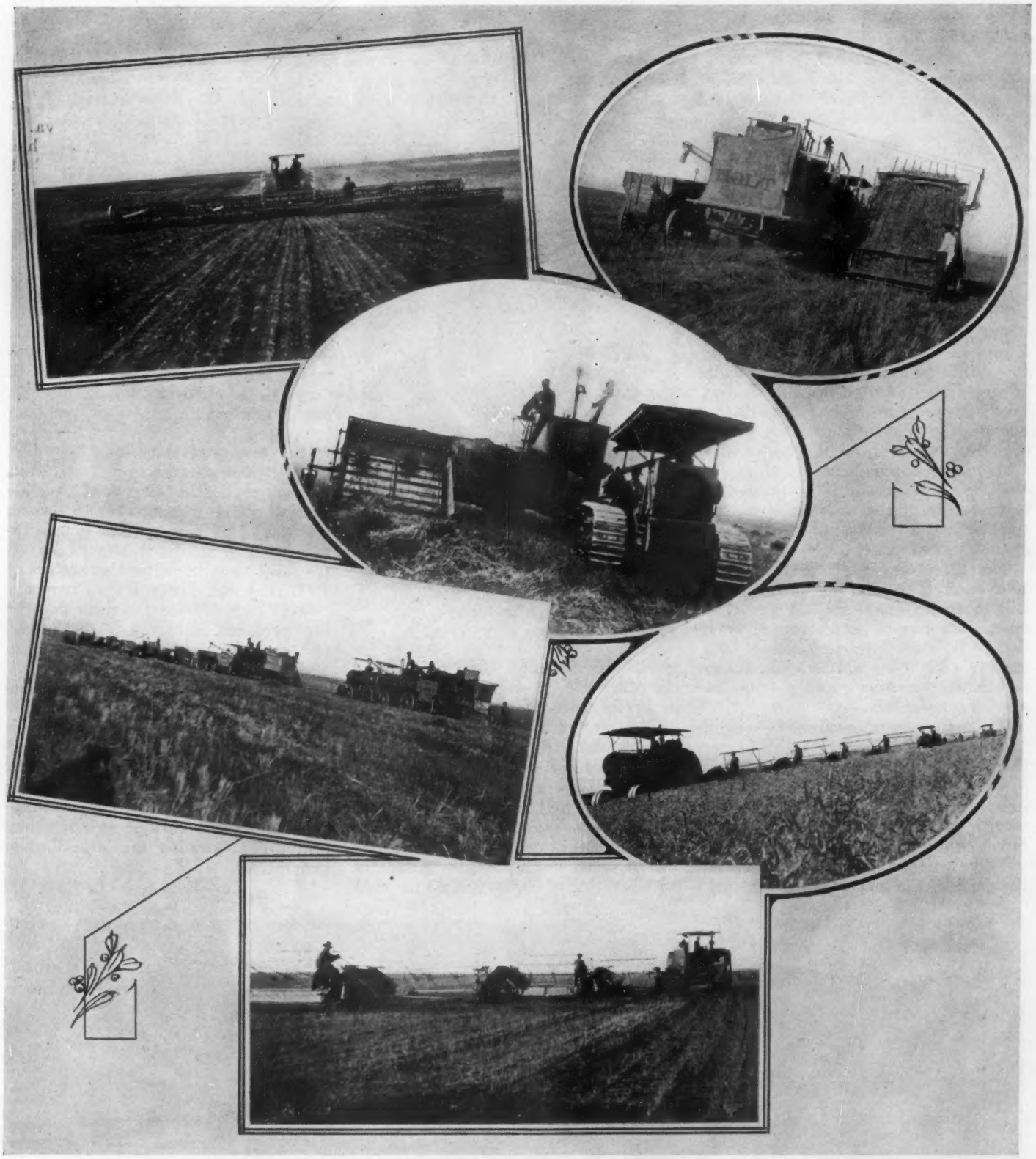
The largest turbine now running, the 91,500 kw cross compound unit, is located in the Crawford Avenue Station of the Commonwealth Edison Company at Chicago. The high pressure turbine drives a 33,000 kw 85 per cent power factor generator at 1800 rpm and a 3500 kw 75 per cent power factor service generator and the low pressure turbine a 55,000 kw 85 per cent power factor generator at 1200 rpm and a 500 kw exciter.

One of the tandem compound turbine generator sets being built for the Southern California Edison Co. is practically completed at the Schenectady Works for installation in their Long Beach Plant, No. 3. When this unit is started it will be the largest tandem compound turbine in operation, and will be driving the largest main generator.

(*Continued on page 284*)

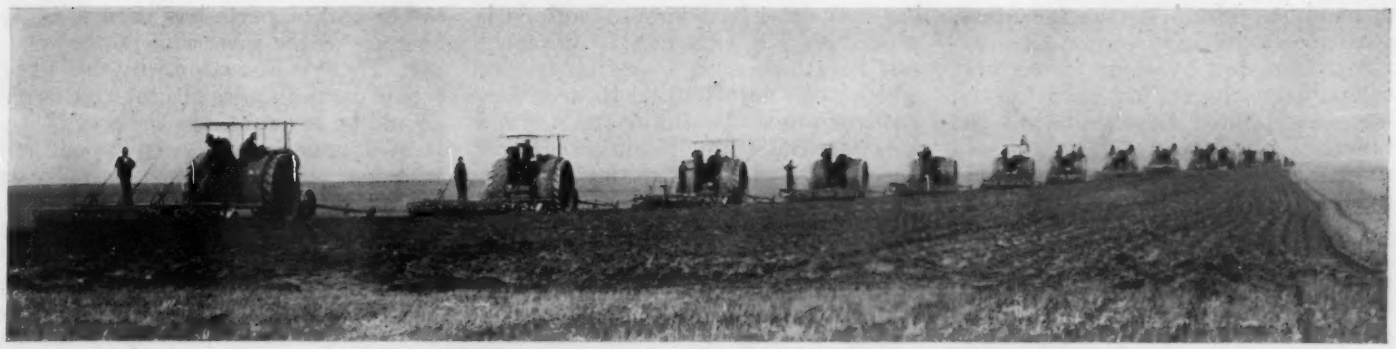


LARGEST TANDEM COMPOUND UNIT IN THE WORLD
This 160,000 kw turbine has recently been ordered for the East River Station of the New York Edison Company



THE LATEST DEVELOPMENTS IN FARM MACHINERY

A seeding and packing machine (*upper left*) 60 feet wide. It works 150 acres a day with a labor cost of eight cents per acre. (*Upper right*) A modern "combine" threshing grain from windrow. A saving of three dollars an acre is realized with this machine. (*Center*) The latest type of combine threshing directly from the shock rows at a total cost of but five cents a bushel. (*Lower left*) Harvesting a 10,000 acre field. Note the bags of grain being put directly into the wagons. (*Lower right*) Reaping an immense field. (*Lower center*) Harvesting 30 bushels of wheat per acre with 15 inches of rainfall.



A WORLD'S RECORD IN THE USE OF FARM MACHINERY
Fourteen of these tractor-drawn plows consistently work 640 hours per day

Agricultural Engineering

A survey of the opportunities for the engineer in agriculture with a description of some of the technical problems facing the farmer today

By THOMAS D. CAMPBELL
President Campbell Farming Corporation,
Hardin, Mont.

THE biggest industrial opportunity in the United States today is in agriculture, and the brightest future for the technical man is in agricultural engineering. Farming as an industry is the nation's largest business. In terms of investment it bulks larger than all other industries combined. It is greater than all the country's manufacturing business, transportation, and mines combined. Farms and farm properties include about one-fifth of our entire national wealth, and the products of the farm, together with manufactured products, equal half of our exports.

Had any of the Pharaohs who lived several thousand years before the birth of Christ visited the United States one hundred years ago they would have found but little difference in the method of tilling the soil from what the Egyptians used in the Nile Valley when they were erecting their pyramids. Most of our development in the improvement of agricultural machinery has come within the last seventy years and the great portion of that has been done by manufacturers in the United States.

It is not over one hundred years since ninety to ninety-five per cent of our people lived on farms and produced all their own requirements, including food and clothing. They consumed everything they produced and had nothing to sell. It was not until the development of our transportation systems, the opening of new country, and the growth of cities that the farmer began to produce a surplus, and this surplus has been one of his problems ever since, making it necessary for him to compete in other markets, and because of this competition has had to reduce the cost of production.

The reduced cost of production has been made possible by the ingenuity and progressiveness of the American manufacturer of agricultural machinery and, as a result, the American farmer produces every food commodity with much less man hours than any other country in the world.

The first great steps in this reduced cost of production were the invention of the binder and the cotton gin. Later came the improved types of threshing machines operated by horse power, then by steam, and later by the internal combustion engine, until machines were produced which can thresh over four thousand bushels of wheat in fourteen hours. But real economy in harvesting and threshing was not attained until the invention of the combine. The combine has had to go through the universal opposition that every new machine encounters, but has finally proven its merit, and it is my belief now that no farmer in the United States with one hundred sixty acres or more of land can afford to be without a combined harvester and thresher. The present combine at a reasonable cost is the most outstanding development in agricultural machinery that has ever been accomplished. It has done more to reduce the cost of harvesting and threshing than any other method which has been developed. The cost of harvesting and threshing with the combine has been reduced to approximately $1.00 per acre, while under the old method the cost was from $2.00 to $3.00 per acre more. There are still, however, some objections to the combine which we have eliminated by means of the windrow method of harvesting and threshing. This method consists of cutting our grain and depositing it in windrows and eliminates the cost of twine, the necessity of a man on each binder, the cost of shocking, and the cost of gathering the shocks from the field for the stationary threshing machine. Both types of machine are illustrated on the opposite page. The grain matures in the windrow even better than in the shock and the threshing is completed within a few days after threshing. This method makes it possible to use the combine in practically every country where wheat is grown.

This short summary brings us to the present era and, while the development has been great, there has, with the exception of the combine and the internal combustion engine, been but little change in other machines in the last twenty-five years. Other industries have increased their output per man many fold. Automatic machines have made it possible for one man to do the work of from five to thirty. Larger locomotives have made it possible for the same train crews to haul several times the number of cars they could move thirty years ago, but in a sense the farmer is still driving four horses.

There, of course, have been some reductions in production costs that have been accomplished by the farmer, but he has not had the chemical laboratories or mechanical departments to decrease these costs as they should be done, and he has had to depend upon the experimental work of the manufacturers of his machinery and upon the Department of Agriculture. The manufacturers have attempted this in various ways, but they have been reluctant to give the farmers the improvements the other industries have gotten, because of the experimental costs and, primarily, because the farmer did not

demand it. Many of the machines, particularly internal combustion engines, marketed by some of our best companies during the last twenty years, have contributed largely toward the failure of our farmers. They have sold mechanical monstrosities which could not be operated by their own experts, much less by inexperienced farmers. They have urged farmers without any mechanical ability to buy equipment which requires adjustments in thousandths of an inch, and the best evidence of the inefficiency of these machines is that their abandoned wrecks are scattered over the entire farming area of the United States. It was impossible for the most intelligent farmer to operate them successfully. This has done a great deal to prejudice many people against power farming, particularly country bankers, and the expression that "No tractor farmer can succeed" is quite common among the heads of rural banking institutions.

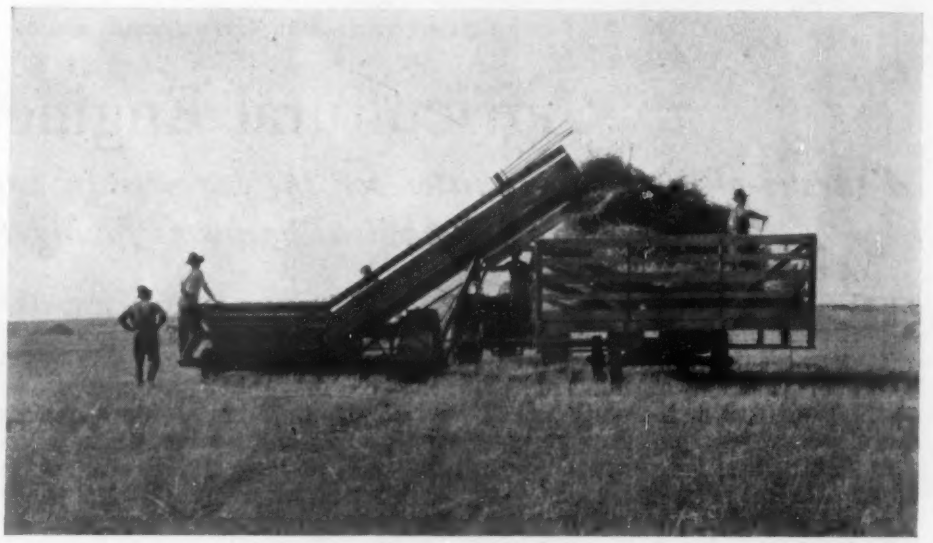
It is common practice for people to criticise. It is easy to find fault without being able to suggest remedies. I have read so many articles of late and have heard so many discussions in regard to what is wrong with the farmer that I cannot help but ask the question sometimes, "What is wrong with the rest of the people?" I know for certain that the fault is not all with the farmer. It occurs to me that our Department of Agriculture or agricultural colleges and our manufacturers can do a great deal towards solving the farmers' problems by the application of agricultural engineering.

The Department of Agriculture has, for many years, done great things for our farmers, particularly along academic lines such as agronomy, soil tillage and the treatment of seeds. Very little attention, however, has been given to the practical or cost production side of farming and that is the one thing the farmer must do. When we have a surplus which we must sell in foreign competition we must do as all other manufacturers do, namely, reduce the cost of production or get tariff protection. I am not in any way unmindful of the advantages of the Department of Agriculture and consider information we have gained from it one of the big factors in our success, but modern farming is ninety per cent engineering and I do feel that the Department could issue pamphlets showing methods of reducing production costs to good advantage.

Engineers, however, can do even more by building better and stronger machines. Very few agricultural machines except some plows come on our job which can satisfactorily stand tractor operation at three miles per hour. This is not strange. Manufacturers for years have been producing equipment for horses to haul. It is absurd to think that this equipment can be attached to a moving tractor which pays no attention to dead furrows or other obstructions and stand up under the strain. Some of our most progressive manufacturers have been realizing this the past few years and have put experimental machines out for active field operation before being definitely placed on the market. I doubt if there is any statistician in the United States who could accurately estimate the loss in time and money to the farmers of the United States through improperly designed and fragile machinery; for instance, I do not know of a tractor on the market today that comes equipped with the proper width of tires, they are all too narrow. I do not know of a binder made today which has a grain wheel large enough in diameter so that it can go over rough ground or through dead furrows at three miles an hour without ultimately collapsing. If the grain wheel had the same diameter as the bull wheel the binder would last much longer. I do not know of a binder today which has a diagonal brace with a turnbuckle or other adjustment extending from the sickle head end of the platform diagonally to the rear outside end. I do not know of a disc or drill on the market today which should not be reinforced. It is only recently that manufacturers of tractors have been willing to give force-feed lubrication through a hollow crank-shaft; others even refuse governors and safety devices, and none, as yet, have given us a satisfactory spring mounting. Manufacturers of agricultural machinery built steam engines for years, and up to the end I do not know of one manufacturer who furnished the farmer with even a balanced valve.

The cost of parts has been another obstacle in the success of power farming. There is no reason why the list of repair parts on agricultural machinery should be several times the cost that a local foundry, poorly equipped and with less volume, can sell them for at a profit.

Please do not think that I mean to severely criticise the manufacturer of agricultural machinery, or that I have ill will towards them. The very reverse is the condition. They have always been particularly good to us and have been big factors in the success of my family. Farmers would not have had any mechanical improvement at all had the manufacturers not been willing to spend their funds for the benefit of the farmer, but I am trying to emphasize the need of the agricultural mechanical engineer.



MECHANICAL SHOCK LOADER
This machine replaces 12 men and 16 horses

I earnestly believe that farming can succeed, but it means small farms operated by the farmer and his family with no payroll, or it means power and larger farms under scientific direction, industrial management, and the employment of skilled labor at high wages. It is almost impossible for any farmer to succeed on one hundred sixty acres of small grain land. The overhead per acre is too large. This is particularly true of semi-arid land in the Northwest. Any man who can operate one hundred sixty acres of land in the Northwest could easily get $150.00 per month at any kind of work in the city. This is $1,800.00 per year, or about $11.50 per acre overhead. The net average profit on such an acre with the lowest cost of production will average from $2.00 to $2.50 per acre, giving a net profit of from $320.00 to $400.00. This shows that it is economically impossible for a man to succeed

(*Continued on page 282*)

Editorials

OUR FUTURE

The announcement by prominent machine manufacturers of a successful cotton picker would seem to substantiate once more the theory that every industry will finally rest on a machine basis. For all practical purposes, this invention breaks the last thread binding the cotton industry to the manual laborer. It has been the boast of skeptics for years that no machine could ever perform the discretionary operation of plucking out the ripe cotton fibre, but again the impossible has been accomplished, and as a result, another industrial revolution seems eminent.

With the advent of this machine, a social structure built up in past centuries bids fair to be disrupted. In place of the slow moving, inefficient, and avowedly lazy manual pickers, one machine with two workers will do the work of many, and do it quickly and more efficiently. This means that thousands of laborers will have to readjust themselves to a "machine age." But this need not be a too terrifying prospect. Almost every industrial change has called for readjustment on the part of the workers, and yet it is admittedly a fact that in no former age has the general plane of living conditions been higher. In fact, it would seem that the level of luxury rises as a function of the increasing use of machinery. We therefore look forward eagerly to the time when, not only the operation of cotton picking, but all agricultural operations shall have been reduced to an exact science. If we assume the same measure of success in this field that science has shown in its other fields of endeavor, it is safe to predict that science in agriculture should eliminate all such evils as food shortage and the lack of raw materials for fabrics, ropes, rubber, in short, for all things based upon an agricultural product.

If we draw more personal conclusions from the prospect of an ever increasing use of machinery, we see that the phrase "We Engineers" will continue to have more and more importance (and responsibility) attached to it. With the advent of the machine age we may expect nearly all problems to be technical or approachable from the scientific viewpoint. To meet these problems there must be a large number of men with trained minds and trained wills of the highest type. The importance of the self-made man must of necessity diminish, yielding place to the technical graduate. But the graduate must also be specialized. Each field of engineering is sufficiently vast to tax the very best of capabilities. Therefore the view of the future unfolds to us as an ever larger field for our particular professions. We see that the future condition of the human race is largely dependent upon our achievements and upon those of our successors. We are now in a state of preparation for those achievements. At our command are the most modern facilities, the latest texts; even the personal opinions of the acknowledged authorities on many subjects. In addition, we have the aid of our student organizations, professional societies, and publications. We are in the acknowledged educational center of the country, in a school whose reputation stands unchallenged at home and abroad. Our opportunities seem limitless.

May we have the strength to so use our talents that we, like the cotton-picker, may inaugurate an era in which science shall rule, and rule supreme; for real science is truth, and truth rules the world.

THE COVER

This month our cover is an interesting lithograph of "The Tuscania at Glasgow," by Muirhead Bone. This artist has made a great many industrial drawings and has always shown a keen interest in shipping and the other industries of Great Britain. He has made a contribution to British art similar to that of Joseph Pennell to American.

AS OTHERS SEE US

In The Tech Engineering News for January, 1927, there appeared an article entitled, "Purdue's Personnel System," covering a subject which, we believe, should be of absorbing interest to every Tech man.

For seven years, the schools of engineering of Purdue University have applied a personnel system with decidedly beneficial results. In brief, the purpose of the system is to improve the personality and character of the student, analyze his vocational fitness, and aid him in securing and holding satisfactory employment after graduation. This is accomplished, not by the usual methods of the so-called intelligence tests, but by obtaining and averaging the opinions of a wide variety of people in direct contact with the student himself.

Near the completion of his freshman year, the student fills out certain reference blanks in which he gives the names of fifteen of his acquaintances — five students, five teachers, and five persons from outside life. To each of these is sent a form on which the person grades the student as to address and manner, attitude, character, cooperative ability, disposition, industry, initiative, judgment, leadership, and native capacity. Each of these terms is defined, and each item marked on a basis of ten.

In order to eliminate prejudices, the fifteen ratings are then averaged, and a composite opinion thus obtained. If the student is particularly low in general, or falls short along one or two lines, he has a conference with the director of the personnel system, whose entire time is devoted to this type of work. The matter is discussed, and ways of improvement are tactfully suggested. The process of rating is repeated in the junior year, in order to check the results of the earlier work. Should the student still lack certain qualities, he has, during the senior year, another opportunity to improve.

We feel that the application of such a system would be highly practicable and beneficial at Technology. It has often been pointed out that many Institute graduates are more than sufficiently trained along technical lines, and yet fall woefully short in those qualities which go to make up that intangible something called "personality." We all lack that power "to see ourselves as others see us," and to know one's own faults is perhaps the most difficult knowledge of all.

Without a realization of his objectionable characteristics, a student is greatly handicapped in business and social life. The personnel system, by pointing out what is commendable in his personality and by constructively criticizing his faults, can do much to develop an engineer whose chances for success are much greater than those of one whose abilities lie in technical training alone.

Since 1920, this system has been tried out on a working basis, and in that time hundreds of complimentary opinions have been expressed. What Purdue has done, Technology can do, and in omitting this form of student analysis, the Institute fails to give its undergraduates the greatest possible amount of training for an engineering career. It is our belief that the establishment of such a system would do much to better the character and personality of Technology men, and as such, we recommend to the powers that the matter be given serious consideration. We shall be very glad to publish in these columns in subsequent issues the views of those who believe as we do, or of those who will be so kind as to point out the error of our ways.

The Engineering Field

Abstracts from the leading professional and trade journals

Ice Control by Thermite. While until recently dynamite was the only instrument used in dislodging icepacks, it was employed not as a preventative but only as a last resort. Because of its explosive force, dynamite cannot be used near bridges or structures of any kind. Thus, a material was sought to replace it, such that it could be readily applied under the most difficult of conditions, be moderate in price, economical to use, and safe to handle. Such a material has been found in thermite — an endothermic mixture of aluminum metal and iron oxide.

The efficiency of thermite lies in the fact that a very high temperature, 2500-3000 degrees centigrade, is produced in a few seconds. While the real number of heat units per pound of material amounts only to 1500, such energy delivered from a body at a very high temperature is more effective than much more energy released at a lower temperature. When the molten iron released by the reaction comes in contact with the ice or water it decomposes the water. This rapid evolution of gas causes a "slow explosion" which cracks the ice and loosens it. Because of this it may be used in settled communities and near structures without causing danger to life or property.

The actual amount of ice melted by the thermite for the heat liberated is small compared with the heat of fusion of ice. The important fact is that the output of energy is in a penetrating heat ray, which pervades the whole mass of ice and honeycombs it, thus causing the jam to break up gradually but surely.

In one instance, several ninety-pound charges of thermite were enough to break up a million ton ice jam within twenty-four hours.

Testing Radio Tubes by machinery is now being done by a leading American vacuum tube manufacturer. The device consists of a revolving disk several feet in diameter, with sockets for the tubes mounted on one face. As it revolves, the tubes are connected successively to circuits which test them for the essential characteristics of a good tube. If one fails to measure up to standard, an electro-magnetic plunger located behind the machine pushes the tube into a basket for further examination. While the best human operators can test only 2000 tubes per day, this machine easily examines 30,000, and with a much higher degree of accuracy.

A New High Speed Camera for motion pictures built on a very simple principle has recently been demonstrated in this country by a Japanese inventor. A wheel of about two feet in diameter is accurately ground with highly polished surfaces on its circumference. The object to be photographed is reflected from these polished surfaces on the revolving wheel, to a cylinder on which the film is helically wound. By having the wheel and cylinder revolve in synchronism and the cylinder at the same time moving along its axis, a new portion of film is continually presented for the reflected picture. The camera is capable of taking 20,000 pictures per second.

An interesting, and at the same time, useful application of the camera is in connection with aerodynamics as it is easily possible to photograph the flow of warm air over the wing of an airplane.

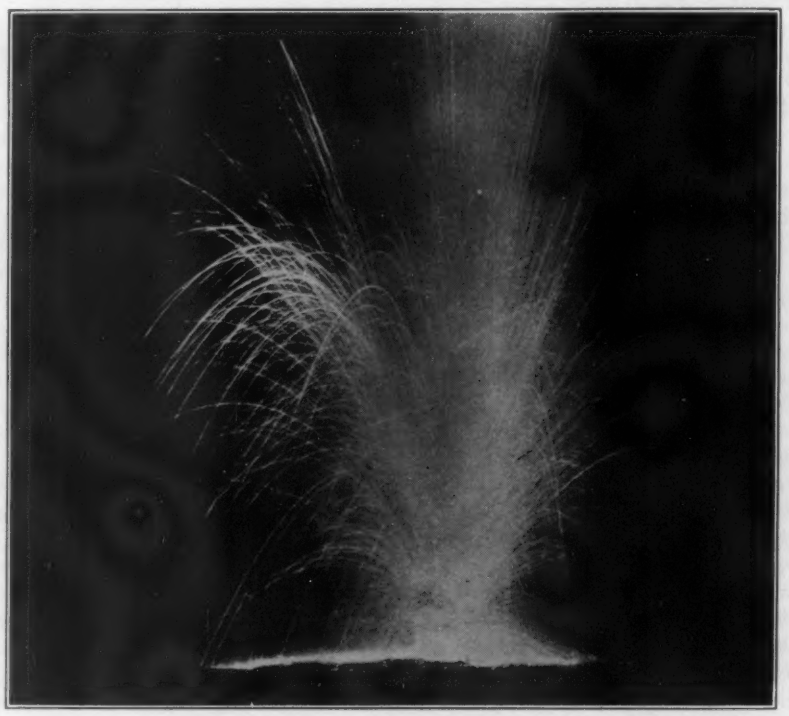
Automatic Lighting of Airports by the incoming plane has recently been successfully accomplished. Essentially, the invention consists of a device which traps the drone of an approaching airplane and changes it into electrical energy.

The "ear" of the mechanism consists of a loud speaker, working in reverse order by inhaling rather than exhaling sound. The auditory section is completed by a microphone. After initial amplification, the impulse is received by a resonant circuit set timed to the dominant frequency of the airplane. Then a second amplifier is included which magnifies the result 100,000,000 times.

In order to prevent any sporadic transient noises from operating the mechanism, a time limit relay is inserted. With this feature nothing less than the continuous hum of a moving plane will light the field.

Along with the invention of this relay it was necessary to devise some sort of lighting apparatus which would furnish sufficient illumination and at the same time eliminate any glare. The unit as designed consists of a twenty-five inch drum fitted with vertical, lateral, and in and out focusing adjustments, and a large parabolic metal reflector so arranged that all reflected rays come within a three degree divergence. When equipped with a plain lens and a fifteen-hundred watt lamp, the intensity is about three million candle power.

By spacing a number of such units on the side lines at intervals of three hundred to three hundred and fifty feet, sufficient penetration is obtained even for large fields and the units can be individually adjusted to take care of any unevenness of the ground.



Courtesy Franklin Institute

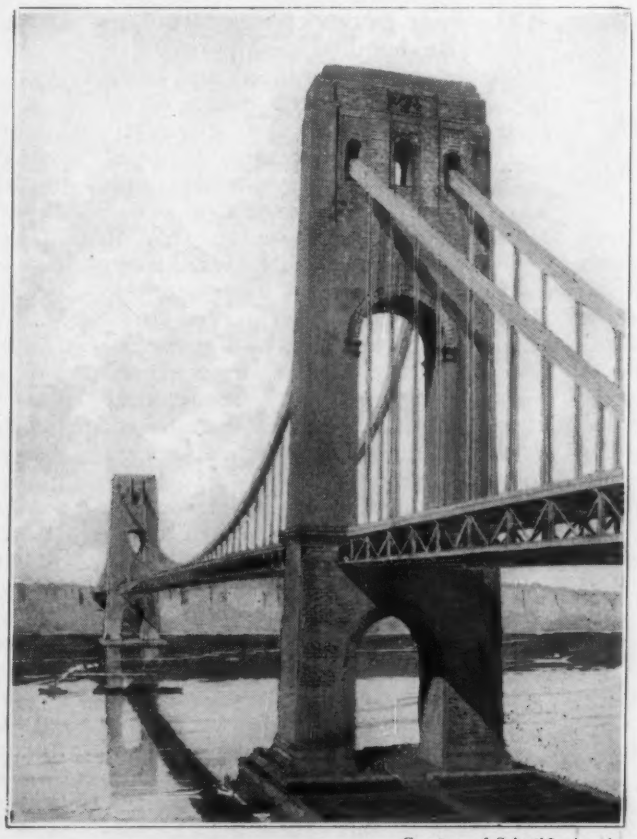
A CHARGE OF THERMITE ACTING UPON ICE

The Largest Span Bridge in the world according to the present plans will soon be built across the Hudson River between Fort Washington and Fort Lee. While the largest single span is now 1750 feet long, this new one is to be almost 3500 feet long. From beginning to end it will include 4800 feet, with each of the main supporting towers 650 feet from either shore.

To resist the cable pull on the New York side, a huge concrete anchorage will be built weighing 370,000 tons. (The whole structure will weigh over 1,000,000 tons.) On the New Jersey side the span strikes the Palisades about 50 feet from the top. The anchorage here consists of 250-foot tunnels bored into the cliffs, through which the cables pass to enormous steel grial-lages embedded in the rock. The tunnels are subsequently to be filled in by concrete, thereby preventing any corrosive effect due to the atmosphere.

The cables themselves will consist of 28,500 number six galvanized steel wires. While each wire can stand 6000 pounds, the pull under maximum load will be only 2300 pounds, and thus it is seen that a generous margin of safety has been provided for.

As initially carried out, the bridge will consist of the two anchorages, two 650-foot steel towers, and the complete cables. A single deck will provide room for four lines of vehicular traffic and two passenger footways. Later a lower deck will be built for rapid transit on the level of the lower chord of the stiffening truss. To carry this additional load and at the same time to bind the whole together, the towers will be strengthened by enclosing the original steel with concrete.



Courtesy of *Scientific American*

PROPOSED HUDSON RIVER BRIDGE

The Fort Lee-Fort Washington Project according to the architect's drawings

Diesel Electric Ferries have recently been put in service on San Francisco Bay. Four six-cylinder four-cycle Diesel engines connected directly to four 275-kilowatt 250-volt generators and four 40-kilowatt, 120-volt exciters form the power plant. The generators, connected in series, deliver 1,000 volts to two propulsion motors, one in the bow, one in the stern. Variations in the speeds of the motors are obtained by varying their magnetic fields.

The advantages of this type of craft over the steam driven ferries are fourfold. Three of the Diesel engines can give the required output; this permits the overhauling of one of the power units while the ferry is in operation. The machinery is so compact that it is installed entirely below the main deck, leaving added space for passenger vehicles. The arrangement of the motors gives greater ease in maneuvering. There is also a great saving of fuel, as Diesel ferries consume one-seventh as much as those driven by steam.

The Leaching of Copper Ores has been greatly aided by a new process of agglomerating fine materials. The method simply involves the mixing of dry crushed ore with a moistening agent until the finer particles cohere together or adhere to large particles. Leaching, or dissolving out the metal, is then accomplished in open heaps by downward trickling solutions. Drainage must be kept open at the bottoms of the exposed heaps and the solution on the surface must not be allowed to cool. This makes possible the profitable treatment of millions of tons of low grade talings from copper concentrates containing from 2 per cent to 1 per cent of copper, as well as large tonnages of ore that slime in crushing or that require fine grinding.

X-Rays in Art. Everyone is more or less familiar with the use of X-rays in the various branches of science, but few are aware of the fact that X-rays can be employed for determining the authenticity of old paintings.

The age of oil paintings is judged roughly by the density of the pigments used. The paints employed by the earliest artists and the masters of the Renaissance were composed largely of finely ground minerals and earths. Modern paints are of chemical composition and lack the density of the older pigments. Artificial ultramarine first appeared in 1828, cadmium yellow in 1846, and chrome green in 1862.

Because of their density, pigments cast shadows on a sensitive plate when exposed to X-rays, and thus the experimenter is able to form an estimate, not only of the age of the pigment, but also of its condition, although the surface may have been repainted or obscured by dirty varnishes.

Just recently a work of Frans Pourbus the Younger was discovered by X-rays under a mediocre panel which had been painted over the original during the eighteenth century. In this instance, the differences in the intensity of the shadows on the film were due rather to variations in thickness of the pigments than to variations in substance. The X-rays showed the original painting to be uninjured by the repaint, so the outer paint was cleaned off, and the painting restored to its pristine beauty.

A study has been made of a number of X-ray films of the old masters, and it has been discovered that each artist has his own manner of working up his finished idea from the first outlines of the picture. Through a study of this brushwork and underpainting, a thorough knowledge of the technique of the artist may be obtained, and the authenticity of the picture thus determined.

Due to the advent of X-rays in art, the connoisseur has more information at his command than formerly, as he can now study the artist's preparatory brushwork as well as his finishing strokes. The true conditions of paintings may be discovered and the work of preserving and restoring them can be more readily done. Also, museums and private collectors may use the X-rays in testing paintings to see if they are forgeries, repaints or genuine.

Once a laboratory curiosity, today X-rays are constantly being applied in the most varied forms of everyday life.

Departmental Notes

Courtesy of *Technique*

PROFESSOR EDWARD F. MILLER

MECHANICAL ENGINEERING DEPARTMENT

DURING the past year there have been a great many problems brought to the department by the different industries. A few of these problems were of such a nature that they could be assigned to students working for a Master's degree, many however, including a number handled by the Division of Industrial Coöperation and Research, being of a confidential nature, were undertaken by the staff.

Some of the more important investigations carried on in the Strength of Materials Laboratory were the following:

Nitriding of special steel.

Hardening and tempering of hypodermic needles.

Heat treatment for special threading tools.

Mechanical operation of hack saws.

Quick hardening cements.

Carbon and Nickel steel boiler plate.

Malleable iron unions.

Oilless and other special bearings.

Tests of special oils.

Durability of certain floro and roof coverings.

The valuation of stone quarries for road work.

The effect of nickel on the tensile strength of cast iron. (On page 258 of this issue, THE TECH ENGINEERING NEWS is publishing a full discussion of the use of nickel in cast iron. The authors are with the International Nickel Company, the foremost authority on the use of nickel in steel and cast iron alloys.)

Effect of lime on the compression strength of cement.

A motor generator set supplying single phase current to the electric furnaces in the Heat Treatment Laboratory was installed early in the year. Aside from this there has been no addition to the equipment with the exception of the usual replacements of measuring instruments and micrometers.

In the Textile Laboratory a very extensive investigation was conducted during the last summer on sewing threads and the effect of moisture on threads.

A new and approved method of measuring the diameter of rayon filaments and of counting the number of filaments per strand has been perfected.

The finer grades of rayon contain about one hundred and twenty-five filaments per strand, the strand being but little over one-hundredth of an inch in diameter.

This laboratory is now equipped with apparatus which will photograph any textile fibre and even a cross section of a fibre.

The Gas Engine Laboratory, known as the Ordnance Gas Laboratory — Building 21 — has been worked to its capacity. In addition to the regular class instruction a great deal of experimental work leading to a development along new lines has been undertaken. The more important investigations are the following:

(1) Two single sleeve valve engines were built, one being mounted on a dynamometer, the other installed in a road test car which was driven 8000 miles during tests of carburation and tests of intake manifolds. No mechanical troubles developed during the runs. This engine has fewer moving parts than any four cycle engine: it is capable of being run at high speed and it is cheap to build. Work on this engine is to be continued during the coming year.

(2) An investigation of water injection into the exhaust manifold of a modern marine engine: its effect on the cooling of the exhaust pipe and on the elimination of danger of fire. From these experiments the proper location of water injection connection was determined and the troubles previously experienced due to warped valves eliminated.

(3) Design, construction, and testing of a new intake manifold for a modern marine engine.

(4) Special work on Combustion Phenomena which was carried on last year and which is to be continued during the present year showed that there was with the gasoline engine some probable substantiation of the hydroxylation theory of fuel combustion. This theory enables much clearer and specific explanations to be given for certain phenomena that occur in these engines. It seems that there is probably some mathematical relation between the combustion process as it occurs in the engine and the fundamental features of design of the engine.

(5) Investigation of a brake-testing device used for testing motor vehicles.

(6) Tests of a Ricardo head versus a standard head on a Ford engine.

(7) A study of the draw bar pull of a ten-ton tractor dragging a snow plow. This led to the design and construction of a special type of traction dynamometer.

A Whippet was purchased for road test work and is now part of the regular equipment.

The following pieces of apparatus have been loaned to the laboratory:

A Buda marine engine.

A Willys Knight.

A Steel Sleeve Panhard Knight.

A new supercharged Mercedes capable of over 110 miles per hour.

A new Bugotti with engine speed 7000 rpm.

An Austro-Daimler speed car.

A new Minerva Knight.

Current models of most American cars are loaned to the laboratory upon request. Professor Fales recently obtained from the General Motors a copper-cooled Chevrolet.

About one-third of the equipment of the laboratory is stored either in the old naval hangar or in the basement of Building 1. As needed, it is shifted from storage to the laboratory.

During the coming year the department has been allotted the services of a research assistant who will spend his entire time in this laboratory.

The Steam Laboratory has installed a Fitchburg unaflow engine and a Skinner unaflow is now in process of erection. A tandem compound McEwen engine with 25 cycle generator was removed in order to give room for setting the Skinner.

The Machine Tool Laboratory has added the following to its equipment:

A hydraulic grinding machine.

A Universal tool and cutter grinder.

A nibbling machine.

An electric arc welder.

A monorail conveyor.

A motor generator set giving single phase current for use in the welding machines in the Machine Tool Laboratory has been installed at the south end of the second floor of the engineering laboratory. This location was chosen as the crowded condition of the shop made it inadvisable to use for this

equipment space which might be needed later for some machine tool.

Two theses carried on in the Power Measurement Laboratory in the basement of Building 5 were of exceptional merit.

One on the "Friction Losses in Gear Teeth," the work of a graduate student, was a continuation of the research on the Lewis gear testing machine loaned us by the American Society of Mechanical Engineers: the other, "An Investigation of the Flywheel as a Dynamometer" was the work of two undergraduates of the class of 1927.

There have been a number of gears donated by the various gear makers for use on the gear machine.

The Jones and Sampson Company have loaned a constant speed motor attached to a Reeves variable speed drive for the use of the laboratory.

During the past year the department has offered two new subjects:

"Inspection Methods," an elective course of 30 hours by Professor Buckingham.

"Metrology and Dimensional Engineering Standardization," a 45-hour course for graduate students, by Professor Buckingham.

Professor Haven has expanded and completed the method of Haerle's curves for stresses in high speed revolving discs.

A coöperative effort between the Lowell Textile School and the Institute is now effective and two candidates for the M.S. degree are enrolled at Technology.

Professor Adams represented Technology at the Portland Cement Association meeting in Chicago. Professor R. H. Smith and Mr. A. B. English attended the National Machine Tool Builders' Exposition at Cleveland. This was the largest convention of its kind ever held in this country. During the convention week they visited the F. B. Stearns Co., Peerless Motor Company, Warner & Swasey Co., National Acme Company, Case School of Applied Science, Chrysler Motor Car Co., Continental Motor Co., and the Ford Company.

Prof. James Holt spent a week in studying the mechanical equipment of a number of the large office buildings and hotels erected in New York City in the last few years. He and Professor Miller visited some of the power stations of the New York Edison Company where powdered coal was being used as fuel.

Professors Haven and Swett have just published a book on Riveted Joints for Pressure Vessels.

Professor Buckingham has prepared the following:

Worm Wheel Contact: paper read before the A. S. M. E. Annual Meeting, December, 1926, and published in *Mechanical Engineering*, July, 1927, and *A. S. M. E. Transactions*, 1926.

Series of articles on Design Operation and Production of Spur Gears published serially in the *American Machinist* during 1926 and 1927, which are to be published in book form by the McGraw-Hill Book Co. in the fall of 1927.

Series of Progress Reports of the A. S. M. E. Special Research Committee on Gears as follows:

Progress Report No. 4, The Influence of Elasticity on Perfect Gear Teeth.

Progress Report No. 5, The Influence of Errors on Acceleration Loads.

Progress Report No. 6, Elastic Impact on Gear Teeth.

Progress Report No. 7, Influence of Rotating Masses.

Progress Report No. 8, Analysis of Tests on Steel Gears.

Progress Report No. 9, Analysis of Tests on Cast Iron Gears.

Progress Report No. 10, Analysis of Tests on Gears of Various Materials.

Progress Report No. 11, Limit Wear Loads on Gears.

Progress Report No. 12, Load Conditions on Gear Trains.

These reports are being published in *Mechanical Engineering* and are primarily studies on the Dynamics of Elastic Bodies.

EDWARD F. MILLER.

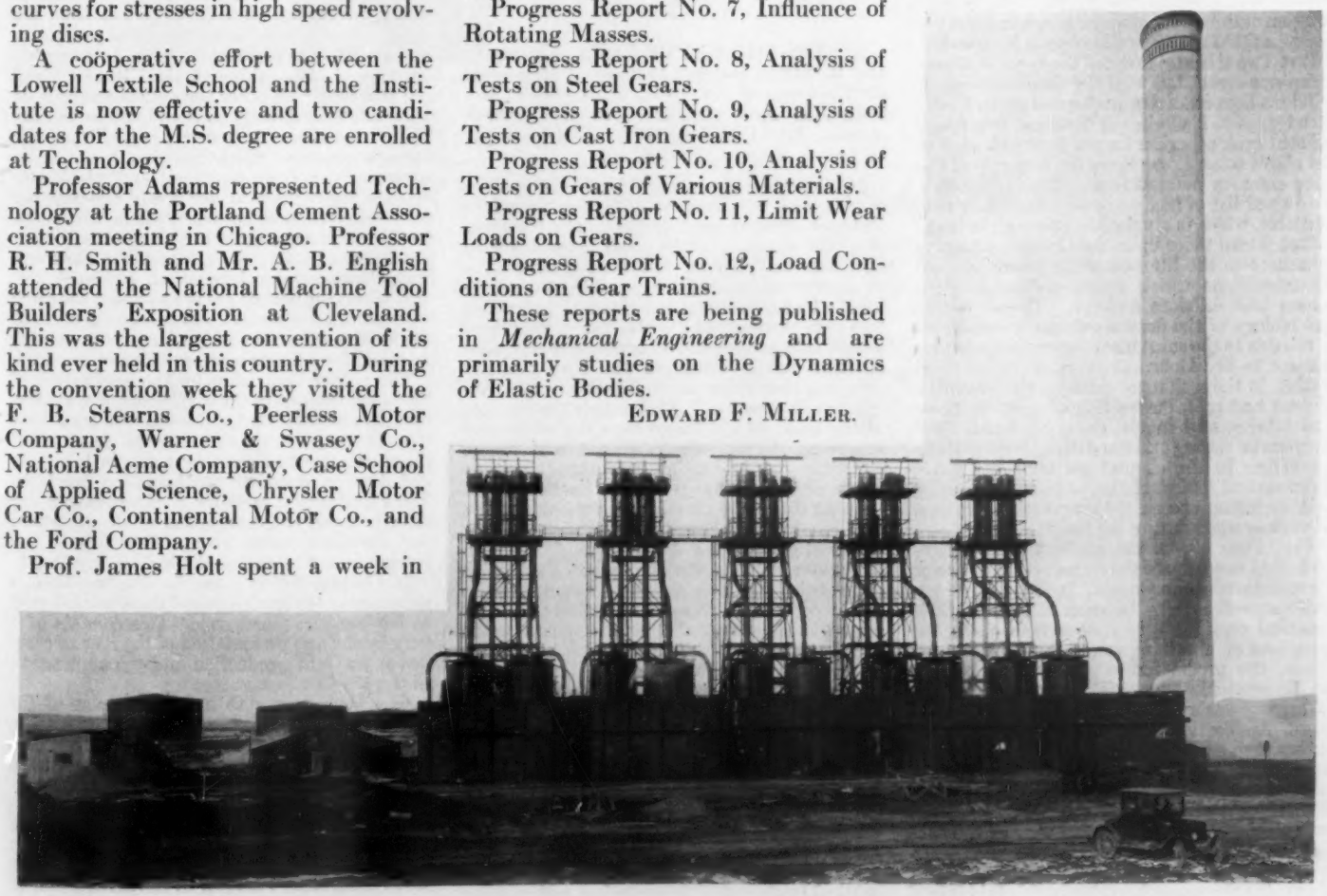
DEPARTMENT OF CHEMICAL ENGINEERING

THE resignation of Prof. R. T. Haslam, director of the School of Chemical Engineering Practice, in charge of the course in Gas and Fuel Engineering, and formerly director of the Research Laboratory of Applied Chemistry, has just been announced. Professor Haslam leaves to accept an executive position with the Standard Oil Company of New Jersey in a research and engineering development subsidiary, the Standard Oil Development Company, which has recently been organized. Professor Haslam, who, for the past seven years, has been identified with every activity of the department, will continue his connection with the Institute in an advisory capacity, news of which is most pleasing to his departmental associates and the faculty at large.

That the Department of Chemical Engineering offers a training peculiarly valuable to anyone interested in the refining end of the oil industry is demonstrated by the departmental history of the last few years.

In 1922, the Standard Oil Company of Indiana took Prof. R. E. Wilson, the director of the Research Laboratory

(*Continued on page 286*)



BATTERY OF DUBBS PROCESS STILLS

One of the forms of equipment in connection with which professors of the Department of Chemical Engineering have done important consulting work in the petroleum industry

Recent Books

This department conducted in co-operation with the Technology Library

THE MICROBIOLOGY OF CELLULOSE, HEMICELLULOSES, PECTIN AND GUMS. *By* A. C. THAYSEN AND H. J. BUNKER. *Oxford University Press, London.*

Little enough is known about the action of microorganisms on celluloses, pectins and gums, *per se*, to say nothing of their action on these substances in nature and in the industrial processes involving their use. The present volume gives a comprehensive account of the information available on the subject at the present time, and the more essential literature. A bibliography of over 600 references is included.

The book is quite technical throughout, being intended primarily for the research worker in this field. For the student of industrial microbiology it is an excellent reference work, covering as it does, the action of both bacteria and molds on celluloses, pectin and gums themselves, together with the microbiological processes involving them.

In regard to nomenclature of organisms, the system followed by Lehmann and Neumann and by Bergey has been followed for the bacteria, while descriptions of the fungi are taken from Rabenhorst. Descriptions of the Actinomycetes is based upon Orskov's recent investigations of the group.

Part One takes up the occurrence and properties of cellulose, hemicelluloses, pectin and gums, and the importance of the microbiological aspect of them. The microbiological aspect is stressed from the point of view of the disposal of the surplus vegetation of the world. The general question of the microbic enzymes concerned in the decomposition of these substances is reviewed.

Part Two takes up in detail the types of microorganisms associated with the decomposition of cellulose, hemicelluloses, pectin and gums. Under each type, *i.e.*, bacteria, ray fungi and true fungi, is listed each organism known to attack each of the above substances. Since the majority of the more common fungi at least, attack cellulose, a good sized list of many species of molds is here available, which is a valuable reference in itself.

Part Three takes up in detail, with extensive references to the literature, the microbiological decompositions which gums, pectin, hemicelluloses and cellulose undergo. The chemistry and biology of the decompositions is considered in relation to the substances themselves, and also relative to the biological processes involved in retting, in the making of ensilage, the formation of peat and coal, destruction of cellulose fibers and fabrics, and in the decay of wood. The chapters on retting and wood decay are especially complete. In the chapter on wood decay are given several tables relative to the fungi causing this, including one on the diagnostic characters of various wood-destroying fungi.

Part Four covers the application of microbiological reactions to the manufacture of two or three industrial compounds. In it are taken up, quite superficially to be sure, since very little practical work has been done in these fields, the questions of obtaining combustible gases from straw, the production of power alcohol from waste vegetable materials, and the production of organic acids by the decomposition of celluloses. Applications and researches are suggested rather than treated, since this field is practically untouched as yet.

I feel that the book fills a real need, in this field, since it gives, for the student of industrial microbiology, a comprehensive view of the subject of the decomposition of cellulose materials, which has not hitherto been available in book form. To the research worker in this field it is of special value for its references, if nothing more. The descriptions of a large number of fungi should make it worth while to microbiologists in general.

The book does not purport to be an exhaustive treatise of the subject. It is rather a reference work, giving a bibliographical review, together with enough descriptive matter to cover the subject for all but the research worker. The authors have done considerable work on the subject, and we believe, are qualified to write such a book.

M. W. JENNISON.

THE INDUSTRIAL TRANSITION IN JAPAN. *By* MAURICE HOLLAND, *National Research Council, Washington, D. C.*

The author, who has recently been visiting in Japan, tells of the increased technical education of its people and the amazing results that have been brought about by this education. He places Japan fourth among the industrial nations of the world in regard to their organization of industrial research.

The results of this research are shown in all their leading industries: such as fishing, silk and pearl culture, and examples are cited by the author that leave no doubt in our minds that Japan is keeping style with the rest of the world in research work. Their modern methods of dealing with the fisheries is similar to our modern packing house, and, alone, shows the rapid advance of science in Japan.

Mr. Holland, in his rather brief, but very concise book, tells of the transition in Japan in a very interesting manner, at times quoting statistics, but making the result very enlightening and broadening.

KINETIC THEORY OF GASES. *By* LEONARD B. LOEB, *Associate Professor of Physics in the University of California. First edition, McGraw Hill Book Company, Inc., 370 Seventh Avenue, New York City, 1927. XVI+555 pp. 76 figures. 6 x 9 in. Price $5.50.*

In his preface the author writes "The purpose of this book is, therefore, to furnish a modern text and reference book on the kinetic theory of gases for student, teacher, and investigator in chemistry and physics. The scope of the book is to present as concisely as possible the various kinetic theory concepts and classical derivations for use by students who are beginning their third year of college work and on to the more advanced students and investigators who wish a handy reference describing more elaborately the phenomena in question." This sounds the keynote of the book, and in many ways the author has succeeded. In fact, there does not exist a more complete and interesting account of the successes of the kinetic theory in English. It is pleasing to find the classical derivations given in detail and with their full rigor, as without these the kinetic theory is a dreary mass of "simplifying assumptions" and a disappointing collection of formulae which do not find substantiation in the experimental data. Any attempt to minimize the failures of the kinetic theory would greatly reduce the value of a book to a large number of readers who desire to find out just how accurate a formula is. It is a rather general fault among workers in the field of kinetic theory, that in the face of a failure they claim that the general analysis is correct, and that they can point out the particular simplifying assumption which introduced the error.

The book begins with a kinetic deduction and discussion of the perfect gas laws, including the kinetic pressure and kinetic temperature hypotheses, followed by a more or less non-mathematical treatment of the mean free path, number of collisions, the simple Clausius equation, and gaseous ion mobility. The paragraph on irreversible compression might readily be misconstrued by the student to mean that the main irreversibility in the compression and expansion of a gas at a finite velocity takes place in the compression cycle.

Chapter IV gives in detail the classical methods for the determination of the distribution of velocities in a gas: first the Boltzmann and afterwards the Maxwell method, although since the Maxwell derivation is the more simple mathematically, it seems that the historic order would have been more natural and in keeping with the general method of treatment of other topics. The credit for the version of the Boltzmann deduction presented is given to Clemens-Schaefer, although it is almost identical with Jeans' treatment of the same subject. There follows an extensive application of the distribution law to the equipartition of translation energy in a gas mixture, various methods for arriving at the mean free path in pure and mixed gases and allied topics, and a treatment of the velocities of molecules and electrons emitted from hot bodies.

Under the heading of "A More Accurate Equation of State" is given a deduction of van der Waals' equation, including both the original derivation and that from the Clausius Virial, followed by a discussion of the methods of evolvation of the equation of state constants from various kinds of experimental data and an application of the equation to the Joule-Thomson effect. Only the classical methods which are in all the textbooks are considered, and thus this chapter is, perhaps, the least modern in the book. Van der Waals' b is still interpreted as a volume or a "repulsive force" and no discussion is given of the interesting view that b arises from the same kind of molecular reactions that produce a. No special consideration is given to Lorentz's equation of state, although the Clausius Virial and practically all other theoretical methods of deduction lead directly to it and not to van der Waals' equation. It seems peculiar that the Lorentz equation which contains a and b in symmetrical volume functions, and which also fits data better tha nvan der Waals' equation has not been given more consideration in textbooks. At the end of the chapter are given several other equations of state which, excluding Kammerlingh-Onnes empirical equation, represent corrections on the perfect gas law to about the same order as van der Waals'. No mention is made of the modern equations which have been derived expressly for a better representation of the data.

The author then takes up the application of the kinetic theory to the coefficients of viscosity, heat conduction, and diffusion. In each case there is first given the experimental definition of the phenomenon followed by a simple deduction and then a complete mathematical analysis. The experimental methods of measurement are described and the comparison of the measured and calculated values given, followed by a discussion of the causes of the lack of agreement.

In Chapter VII is given, for the first time, a summary of the application of the kinetic theory to low pressure phenomena. This consists of a very interesting presentation of the flow of rarefied gases, heat conduction and the application to the absolute manometer.

The book ends with a full discussion of the Brownian motion, specific heats, and the modern theories of the variation of the dielectric constant with temperature, magnetism, and the conduction of electricity in gases.

On the whole the book is a notable addition to the literature on the kinetic theory, and is without doubt the best English text on the subject adapted to classroom instruction, while at the same time, is very helpful to the investigator in physics or chemistry who may have kinetic problems to solve.

JAMES A. BEATTIE.

To improve the machine

Two days after the victory. Yet the squad was hard at it developing a new and formidable attack. Always improving the machine!

Improving the machinery of telephone making has been the unceasing responsibility of Western Electric, since 1882 manufacturers for the Bell System.

If it has been a work big with responsibility it has been equally big with interest and opportunity. Many Western Electric men have found it so.

Among them are those who set new standards in the art of making wire—developed the utilization of organic materials for wire insulation—improved the method of using rubber in electrical equipment—and so perfected the processes of manufacture of cable as to make possible existing long distance communication.

This work of improvement, setting higher standards and then attaining them, goes on and on.

BELL SYSTEM — AMERICAN TELEPHONE & TELEGRAPH CO. AND ASSOCIATED COMPANIES

Western Electric

SINCE 1882 MANUFACTURERS FOR THE BELL SYSTEM

Industrial Illumination Research

(*Continued from page 257*)

influences. The factors which affected production very greatly, and which consequently obscured any possible lighting effect which might be present, were increasing demand for the product increasing efficiency, (operatives becoming more experienced), variation in working material and changes in product and operation.

Another test was started about the same time as the first one and continued over a period of two and one half years. This test was conducted in

FIG. 2. AN ASSEMBLY TEST

Illumination plays an important part in these exacting operations

a large plant in the middle west and was broken up into three separate divisions, corresponding to three different winters.

During the first winter, three different departments were investigated. In one department the operatives inspected shiny metallic switch-jack shells and springs for a large number of possible defects. In the second department the operatives assembled electrical relays. This work consisted of placing the coils, springs and insulators into the proper position and then bolting them together. Figure 2 shows an operative in the process of assembling a relay. In the third department the operatives wound small induction coils on wooden spools.

The general test procedure for each department was the same. First there was a preliminary period, during which the operatives worked under the existing lighting installation supplemented by daylight. The average production rates obtained during this preliminary period furnished base lines for calculating any future production changes.

The various levels of average illumination intensity for the shell and spring inspectors were 3, 6, 14 and 23 foot-candles. The corresponding production efficiencies by no means followed the magnitude or trend of the lighting intensities. The output bobbed up and down without direct relation to the amount of illumination.

The illumination intensities furnished the relay assemblers were 5, 12, 25 and 44 foot-candles. The efficiency of this department increased more or less continuously during the test but not as a sole function of illumination.

The various levels of average illumination intensity furnished to the coil winders were 10, 16, 27 and 46 foot-candles. The production efficiencies corresponding to these periods of different lighting intensities were always higher than the starting level and did not always fall off with a decrease in illumination.

The results of this first winter's test, covering the three departments described, brought out very forcibly the necessity of controlling or eliminating the various additional factors which affected production output in either the same or opposing direction to that which we could ascribe to illumination.

During the following summer, production records were kept of the three departments tested. A consideration of the favorable and unfavorable test factors existing in each department led to the choosing of the coil winding department for another test the following winter. The essential change in procedure for this test was the division of the coil winders into two groups. Each group had an equal number of operatives of equal experience and were so selected as to have equal average productive efficiencies at the start of the test, based on their summer records. One group, called the test group, was to work under variable illumination intensities and the other group, called the control group, was to work under as near a constant illumination as possible considering the fact that the artificial illumination was supplemented by the ever variable daylight. The groups were located in different buildings in order to make the separation complete and in this way reduce the influence of any spirit of competition.

The test group worked under three different average lighting intensity periods of 24, 46 and 70 foot-candles while the control group worked under a more or less constant level of 16 to 28 foot-candles. The increase in daylight accompanying the advancing season was responsible for the large variation in illumination intensity. This plan of having a control group was decided upon as a means of evaluating the effect of illumination by subtracting the output of the control group from the output of the test group. The differential between the two should be related to any increase in productive efficiency caused by the higher levels of illumination intensity.

This test resulted in very appreciable production increases in both groups and of almost identical magnitude. The difference in efficiency of the groups was so small as to be less than the probable error of the values. Consequently we were again unable to determine what definite part of the improvement in performance should be ascribed to improved illumination. However, it should be borne in mind that the illumination intensity furnished the control group was relatively high and may have included the same benefits as the higher illumination furnished the test group.

The following year another test was conducted with the coil winders, using two essentially different methods of procedure. The mixture of artificial with natural illumination during the previous test had resulted in a lack of definite control of the illumination

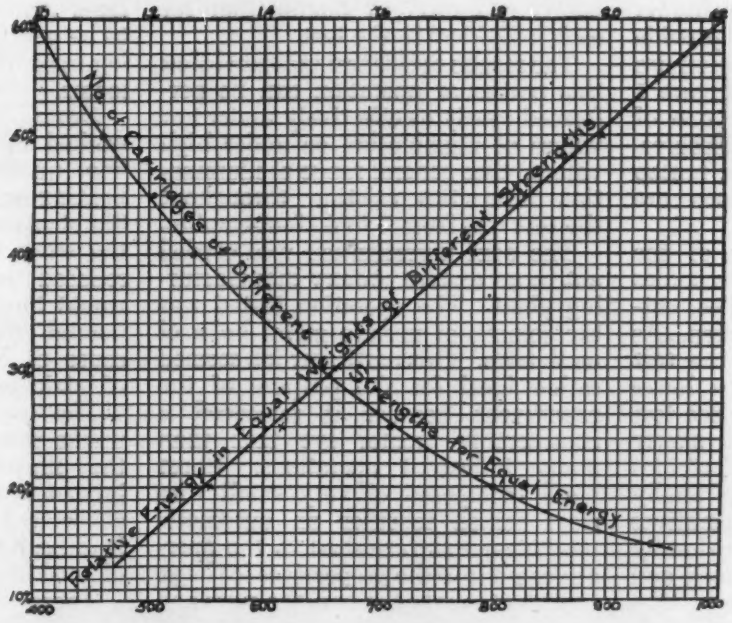
FIG. 3. ANOTHER TEST SUBJECT

The white paper and the necessity for precision make this an effective test

intensities. Therefore, this new test used artificial lighting only. The levels of illumination intensity formerly used were in most cases considerably higher than are found in most plants. Furthermore, the results of the laboratory tests, being carried on at this time for the committee, indicated that the critical point of illumination for this coil winding operation probably was in the neighborhood of 5 to 10 foot-candles. For this reason it was decided to provide intensity levels from 10 to 3 foot-candles in steps, decreasing 1 foot-candle at a time. This, of course, applied to the test group, since it was decided to follow the test control and group method as outlined in the previous test. The control group was to

(*Continued on page 274*)

Action of Explosives


Relative Energy in Equal Volumes of Different Strengths
Strengths for Equal Energy
No. of Cartridges of Different Strengths

Lesson No. 1 of

BLASTERS' HANDBOOK

ALL explosives are solids or liquids that can be instantaneously converted by friction, heat, shock, sparks or other means into large volumes of gas. That sounds simple, but this fundamental principle of the action of explosives is modified by a host of circumstances.

First there are "high" and "low" explosives. Then there are all the circumstances of purpose, methods of loading and firing and handling and storing. Explosives are measured principally by these general characteristics: **Strength, Velocity, Water Resistance, Density, Fumes, Temperature of Freezing, and Length and Duration of Flame.**

Chapter One of the *Blasters' Handbook* makes this seemingly complicated subject very easily mastered. Charts and tables explain relative energy of different strengths. Other characteristics are explained in classroom terms, and amply illustrated.

Many of the leading technical colleges, universities and schools are using the *Blasters' Handbook* in their classroom because of its perfect practicality. Made up by du Pont field service men out of their own experience in a great many fields over a great many years. The textbook of the "school of experience."

You ought to have this experience text-book.
A valuable reference and study work. Yours for the mere asking.
Here's a coupon for your convenience.

DU PONT

REG. U. S. PAT. OFF

E. I. DU PONT DE NEMOURS & CO., Inc., Explosives Department, Wilmington, Delaware

Without cost or obligation on my part, please send me a copy of the "Blasters' Handbook."

Name .....

Dormitory Room No..... Street.....

City..... State.....

Industrial Illumination Research

(*Continued from page 272*)

be provided with a constant level of 10 foot-candles. Physical separation of the two groups was provided by locating each group in an enclosure, being careful, of course, to provide sufficient ventilation and to minimize any feeling of confinement. Figure 1 gives an excellent picture of one of the two identical group enclosures. The lighting installation, fans, burlap screens and working positions are clearly indicated.

The illumination intensity of the test group started at 10 foot-candles and decreased to 3 foot-candles, cutting down 1 foot-candle at a step. As the level of illumination in the test group enclosure changed to a lower value, the efficiencies of both the test and control groups increased slowly but steadily. When the level of illumination for the test group finally reached 3 foot-candles, the operatives protested, saying that they were hardly able to see what they were doing and the production rate decreased. The operatives could and did maintain their efficiency to this point in spite of the discomfort and handicap of insufficient illumination.

An entirely different illumination-production test was conducted in the paper cutting department of an eastern plant. This test involved the use of natural illumination only and was possible because of the very large amount of window space in the room and because the test was conducted in the part of year when the intensity of daylight was strong and getting stronger daily.

The operation performed by the workers consisted of cutting paper napkins from a large roll of paper stock mounted on rollers. The paper was pulled across the lower blade of a large knife and stopped at a spot mark which indicated the place for cutting, but the location of the spot was indicated both manually and visually. The upper blade of the knife was operated by a treadle so that the actual cutting operation was accomplished by a foot movement. As soon as one cut was made, the operative pulled the paper along and the action was repeated over and over. Figure 3 indicates very clearly the operation of cutting the napkins and the brightness of the white paper.

The brightness of the white paper and production counts were read hourly at each operative's machine. Nature was relied upon for the variation in illumination since daylight varies considerably over different hours of the day and also for different kinds of skies, (clear, light clouds, dark clouds, etc.) sufficient variation of illumination for our purpose was obtained. Therefore we had a means of obtaining the hourly production and hourly variation in illumination for each individual in the test.

The results of this test indicated that this particular operation can be performed nearly as effectively under low values of illumination as under high values. The general range of illumination intensities existing throughout the test was from 2 to 40 foot-candles.

The next investigation was carried out in an eastern jewelry manufacturing plant. The operation tested was the joining of minute metal links of mesh bags. This particular job seemed rather ideal for the purpose of the experiment because it possessed a considerably greater eye task than many industrial operations. Sheet mesh (composed of very small wire rings joined together on automatic machines) was furnished to the operatives cut into the proper sizes for bags. In order to make the bag, the sides had to be joined together. The actual operation of joining, as performed by the operatives, was to place the little rings to be joined over one half of a small circular die by using tweezers. The operatives pressed a foot pedal and the upper half of the die came down upon the lower. Simultaneously wire was fed to the dies, cut off, and formed into a ring around the other rings which were to be joined. The number of rings inserted by the operative was recorded by a counter attached to the machine.

Three types of illumination were available — daylight, overhead artificial illumination and local illumination from individual reflectors. The general overhead illumination was used at the operative's discretion — usually in the early morning and late afternoon. Illumination measurements were made at each machine hourly and at the same time the production was read from the counters.

This particular operation was studied in the laboratory at Technology the following year and gave more definite results than could be obtained under the necessarily irregular conditions existing in the factory. With two increases of illumination intensity, a single operative produced appreciable increases in efficiency of production. Before further changes in illumination intensity could be attempted, or the first figures checked, the trained test subject resigned.

A very different class of work was subjected to investigation by conducting an illumination-production test in a large eastern cotton-tape weaving mill. The actual production of the tape was, of course, from power driven looms. However, there was a sufficient number of strictly manual operations requiring close visual attention to be performed to have a direct bearing upon the actual production of the looms.

During the test, the operatives worked under artificial illumination of fine quality furnished by indirect lighting units. This luxurious type of illumination was of especial value for the work because the shadows were reduced to a minimum. Shadows would have had an extremely detrimental effect with direct lighting because of the physical characteristics of intricate mechanisms such as looms.

The results of this test were not unlike those of previous tests in that they illustrated the manner in which influences other than illumination affect efficiency to so great an extent that it is difficult to fully isolate the benefits of good illumination.

These uncontrolled outside influences are many in number and varied in effect. Some of them are beyond the control of the operatives, but many are a direct result of psychological effects bound up in the individuality of the worker. As soon as lessons were learned from the experience of one test and corrective measures applied, additional lesser variables would become apparent to continue the process of obscuring the results.

A partial enumeration of the various factors will bring out forcibly the difficulties and problems of such an investigation. The demand for the produce will cause a large variation in the rate of output. A sudden large increase in orders will result in a large total output but it may or may not cause an increase in individual output. If new workers are employed and have to go through a learning period, the average efficiency of a group will decrease in spite of the increase in total output. If the original employees take care of the increased production, then, of course, the efficiency goes up in proportion. Fear of a lay-off will cause employees to work very hard to hold their jobs. With plenty of jobs available, they will be independent and the tendency is to work more as they please.

Piece rate workers have a different incentive for production than day rate workers. Some piece rate employees perhaps intentionally limit their production in the fear of having a rate cut. A sudden desire for money may result in a tremendous spurt on the part of a piece rate worker. A very marked effect is observed in the kind and amount of supervision applied to work-

(*Continued on page 282*)

Waste Dethroned!

Waste no longer reigns in Industry! Timken Bearings have decreed it! Machinery users are freed of the excessive tax of friction, wear, inaccuracy and under-production.

Power savings as high as 60% and lubrication savings of even greater proportion stand to the credit of Timken Tapered Roller Bearings.

On high speed work Timken Tapered Roller Bearings are being specified for operation at 15,000 r. p. m. On heavy duty jobs Timkens are carrying single loads upwards of 2,500,000 pounds.

On the spindles of the finest machine tools Timkens are making extreme precision a permanent quality. In electric motors Timkens are revealing hitherto unheard of saving and endurance.

In *every* type of equipment the exclusive combination of Timken tapered construction, Timken *POSITIVELY ALIGNED ROLLS* and Timken-made electric steel has brought a new era of economy, precision and endurance.

So great are Timken betterments that it is advantageous in many cases to replace obsolescent types of equipment *at once*. Leading manufacturers in every line now offer Timken-equipped machinery.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**

Professional Societies

(*Continued from page 253*)

plains that his society does nothing for him is one who does nothing for the society. The professional societies are not unions to which one pays dues in support of agents to watch wages and working conditions and fight to keep them up. They are of the character of the clubs and small societies that Benjamin Franklin was fond of forming and participating in. They are societies for mutual association, for improvement of the members by mutual relations, and for advancement of the profession by disseminating knowledge. It is the acts of the members themselves that make the usefulness of these professional societies to the individual participants as well as at large.

A word on a collateral matter may not be out of place. For young men following in the engineering school a course of study of definitely scientific fabric like our electrical engineering course and its ramifications (VI, VI-A, VI-C), reading the papers on scientific and application subjects of the Journal of the American Institute of Electrical Engineers is wisely fortified by systematic examination and some discussion of articles and descriptions printed in commercial journals like *Electrical World*, *Electric Journal*, *General Electric Review*, and *Engineering News Record*. This is a means of securing a fuller knowledge of the practice and applications of today that form the groundwork on which are set the improvements arising from scientific discoveries and scientific analysis. These improvements will compose the greater scope of the applications and practice five years hence when our present students are industriously biting into the practical affairs of their engineering life.

Concrete Specifications

(*Continued from page 256*)

least cement per volume of aggregate. With a known water-cement ratio the greatest volume of aggregate is given by one having a high fineness modulus, namely a coarse aggregate. This is limited by the necessity of keeping away from mixes so coarse that they make harsh mixes and honeycombed concrete. The plots in Fig. 7 (page 256) include the strength and fineness requirements for varying consistencies and for varying size of aggregate.

"SLUMP" TEST
Final height shows the consistency of mix

For example, the mix is desired for a concrete which must give 2200 pounds per square inch in compression at the age of 28 days and whose field consistency is to give a slump averaging 4 inches. The maximum size of aggregate to be used in 1 inch. Consulting Fig. 7 the mix (ordinates) should not be leaner than 1 volume of cement to 5.8 volumes of rammed dry mixed aggregate. The abscissae give the fineness modulus of the mixed aggregate as 5.25. Assuming that the sand and pebbles of Table I are to be used, the proportions of each to give a resultant fineness modulus of 5.25 can be determined from the equation:

$$m = rm_f + (1-r)\, m_c \qquad (A)$$

where

- m = fineness modulus of the mixed aggregate
- m_f = fineness modulus of the fine aggregate, or sand
- m_c = fineness modulus of the coarse aggregate, or stone
- r = ratio of volume of fine aggregate divided by the sum of the separate volumes of fine and coarse aggregates
- $(1-r)$ = ratio of volume of coarse aggregate divided by the sum of the separate volumes of fine and coarse aggregates.

Thus, using a 1:2:4 mix;

$$r = \frac{2}{2+4} = 0.33$$

$$\text{and } (1-r) = \frac{4}{2+4} = 0.67$$

Equation (A) may be rewritten in the form:

$$r = \frac{m_c - m}{m_c - m_f} \qquad (B)$$

In the problem above

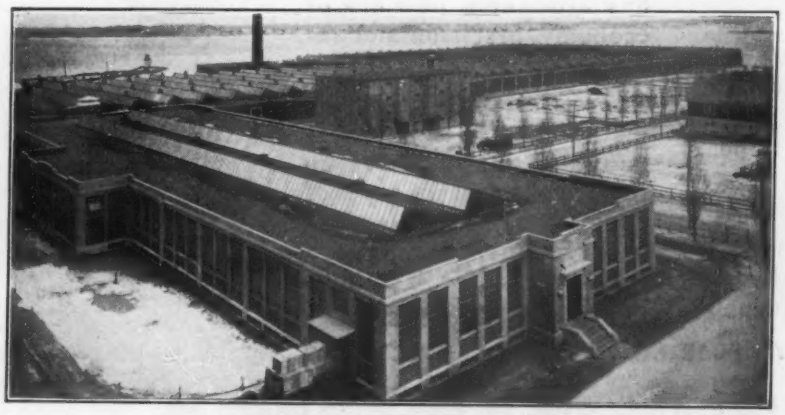
$$r = \frac{6.60-5.25}{6.60-3.70} = \frac{1.35}{2.90} = 0.47$$

and

$$(1-r) = 0.53$$

For every dry rammed volume of sand 1-1/8 volumes of pebbles should be used. This gives much more sand than the ordinary proportions which call for about half as much sand as stone. The

(*Continued on page 280*)



One of the finest textile mills in the world, built by William T. Reed Company. Several repeat orders have been received from this firm.

WILLIAM T. REED COMPANY

BUILDING CONSTRUCTION

201 DEVONSHIRE STREET
BOSTON

We are organized and equipped for the efficient handling of mercantile and industrial building construction of all descriptions.

OKONITE
TRADE MARK

The Standard for Rubber Insulation

FOR nearly half a century the name OKONITE has been recognized in the electrical industry as being synonymous with quality.

OKONITE insulation is a rubber compound containing never less than 30% by weight (over 60% by volume) of wild, dry, Up River Fine Para Rubber with no admixture of low grade rubber, reclaimed rubber or rubber substitutes.

All products bearing the OKONITE trade mark carry with them our unconditional guarantee of excellence and unvarying reliability.

OKONITE is made in but one grade.

The Okonite Company
The Okonite-Callender Cable Co., Inc.
Factories, PASSAIC, N. J. PATERSON, N. J.

Sales Offices: New York, Chicago, Pittsburgh, St. Louis, Atlanta, Birmingham, San Francisco, Los Angeles, Seattle

OKONITE
Pettingell-Andrews Co., Boston, Mass.
Novelty Electric Co., Philadelphia Pa.
F. D. Lawrence Elec. Co., Cincinnati, O.

Canadian Representatives: Engineering Materials Ltd., Montreal
Cuban Representatives: Victor G. Mendoza Co., Havana

DUDLO

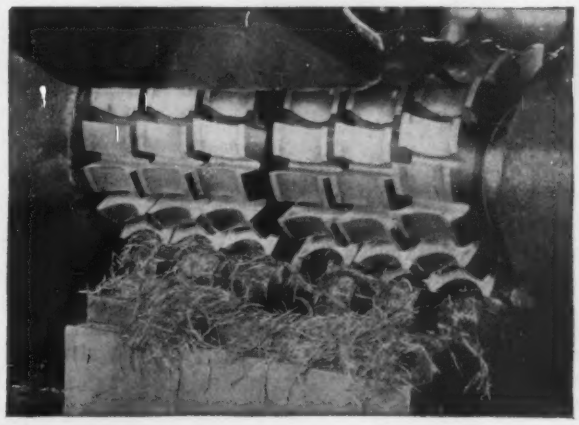
MAGNET WIRE *and* WINDINGS

are standard in four out of five electrical manufacturing plants.

DUDLO

Ask for a copy of the DUDLO folder "Wire and Winding Data". It will help you in your work.

DUDLO MANUFACTURING CORP.
FORT WAYNE, INDIANA



"Special Formed Cutters were used"

MORE and more frequently this statement appears in the description of high production milling set-ups. The advantages of milling the required contour at a pass are becoming more widely recognized every day.

Manufacturers are learning that Brown & Sharpe Formed Cutters, in addition to giving a substantial increase in production, are lower in cost because of their ability to stand up longer between sharpenings.

Above, a gang of six Brown & Sharpe Formed Cutters is in use for a form milling operation on wrench handles. The cut was taken rapidly yet leaving the good finish which was required.

It will profit you to become thoroughly familiar with the line of over 1500 styles and sizes of Brown & Sharpe Cutters. Send for a copy of Small Tool Catalog No. 30, which lists them all and contains considerable information about cutters.

BROWN & SHARPE MFG. CO.
PROVIDENCE, R. I., U. S. A.

Nickel Cast Iron

(*Continued from page 259*)

that the hardness of the alloy iron is due to a solid solution hardening, rather than, as in hard plain iron, to the presence of an excess of free carbides.

Many users anneal their gray iron castings to secure uniform hardness. While annealing destroys many of the desirable characteristics of gray iron, this operation is considered to be justified because of the resultant economies in the machine shop. The losses which can be incurred through using expensive tool equipment, automatic machines and other production equipment upon defective castings are obvious. The use of nickel ensures a material that is readily machinable in the unannealed condition; thus, there is a further gain through eliminating the cost of the annealing operation. This is a great advantage, for the savings in the machine shop are dependent upon the supply of sound castings of uniform hardness. Given the uniformity, a general raising of the level of the physical properties of the metal is to be desired. Frequently the use of better castings enables the machine shop to speed up machining to a point that would be impossible with plain iron.

Castings often crack when natural stresses and strains in the cooling metal cannot escape. Generally this may be attributed to an unequal distribution of combined carbon. If this factor be controlled by the use of nickel, such strains are sufficiently relieved to avoid cracking.

Chromium is frequently added to cast iron in conjunction with nickel. The action of this element on the carbon is diametrically opposed to that of the nickel. Through its combination with the carbon and iron the hard chromium carbide is formed. This constituent is quite brittle and it is therefore necessary, where a hardness obtainable only through the use of chromium is required, to counteract this embrittling effect by the use of nickel. In general, the ratio of nickel to chromium, if the depth of chill obtained in the plain iron composition is to be maintained, should be about 3 to 1. Hardness in excess of 200 points BHN higher than plain chilled cast iron values is obtained in nickel-chromium compositions. Another valuable contribution of the alloy to this material is a 50–75 per cent increase in the strength of the gray iron behind the chill. This is of particular importance for applications such as rolls in which a high hardness on the surface is essential and strength, resistance to shock and a machinable condition in the gray portion of the casting are desirable.

The all-important question remains. Can the use of nickel in the manufacture of cast iron be justified economically?

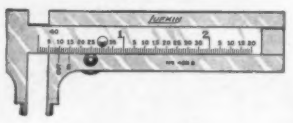
Several factors must be considered before this question can be answered satisfactorily. Bearing in mind the great disparity which exists between the price of nickel and the price of iron, it would appear that the answer must inevitably be "No." Yet a fuller consideration of the figures involved will show that considerable savings can be effected by the use of nickel, and it will be expedient to examine the nature of these savings in some detail.

Local conditions are very important. The sphere of operations of most foundries is strictly circumscribed by the cost of freight. For the same reason the cost of the raw material varies in different areas. Foundry scrap and steel scrap are obtainable in some places at half the cost of pig iron. It has been found that by the use of nickel a readjustment in the ratio of pig iron to steel scrap may be effected to employ a larger amount of the latter. It is obvious that the additional cost of the alloy is justified by this reduction in the cost of the base material. The high sulphur content of off grade iron may also be disregarded, for the toughening effect of nickel on the matrix of the metal overcomes the embrittling effect of this element.

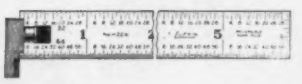
Owing to variations in the composition of the metal produced in the cupola, it is very desirable to be able to add the exact amount of nickel necessary, and no more. The usual method recommended is to add nickel in the form of shot as the metal is poured into the ladle. By doing this the addition may be made with mathematical exactness, interference with production methods is avoided and the alloy content required is definitely secured. For this purpose a special product of the International Nickel Company known as "F" nickel shot has been developed. This material melts at a temperature sufficiently lower than the pouring temperatures employed in iron foundries to ensure its complete solution and uniform distribution throughout the metal.

Nickel cast iron is primarily suited for castings which require machining and uniformity of structure in various sections of uniform strength. Its use has solved many of the foundryman's problems, and the general improvement in the properties of the material resulting from the use of nickel will do much to cause cast iron to regain its original position in the field of engineering materials.

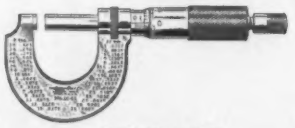
Editor's Note. Detailed information is available on the subject of Nickel Cast Iron. The physical properties, microstructure and general characteristics of nickel bearing cast iron, together with a discussion of their mechanical and economic advantages, are presented in a series of bulletins. These will be supplied upon request by The International Nickel Company, 67 Wall Street, New York City, N. Y.



LUFKIN TAPES--RULES TOOLS



THE COMPLETE SOLUTION OF YOUR PROBLEM OF ACCURATE MEASUREMENTS



SEND FOR
Cat. No. 11—Tapes and Rules Cat. No. 5—Tools

THE LUFKIN RULE CO. SAGINAW, MICHIGAN
NEW YORK WINDSOR, CAN.

KOEHRING

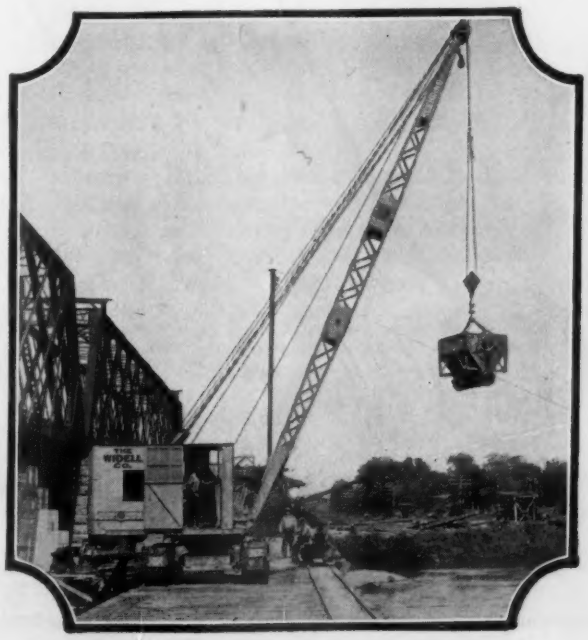
When 1 Crane becomes 4

THE whir of varied operations in the construction field is confidently welcomed by the Koehring Heavy Duty Crane. It is not a welcome springing from a boastful confidence but a welcome coming from the ready adaptability built into a Koehring product.

Only four of the many uses to which the Koehring Crane is adaptable are illustrated on this page. Perhaps the most frequent of these is that of the clamshell bucket which transfers materials and aggregate at the central proportioning plants or in sand and gravel yards.

In the construction of concrete dams, reservoirs and bridges, the crane with a special bucket provides a speedy conveyance for elevating the concrete from the mixer to the forms. With a block and hook it is an exceedingly practical tool in the handling of structural steel for bridges, towers, tanks and buildings. And still another example of its wide utility is often shown in foundation work where it is necessary to drive piles for a solid footing. The Koehring Crane then becomes a pile driver.

Other outstanding uses of the Heavy Duty Crane include clay excavation with an orange peel bucket, the digging of drainage ditches and sewer lines with clamshell or dragline bucket, the lowering of sewer pipe into position with hook and sling, the handling of scrap iron and other metals with a magnet, and the constructing and removing of forms for concrete.



"Concrete—Its Manufacture and Use" is a 210 page treatise on the uses of concrete, including 26 pages of tables of quantities of materials required in concrete paving work. To engineering students, faculty members and others interested we shall gladly send a copy on request.

KOEHRING COMPANY
MILWAUKEE, WISCONSIN
Manufacturers of Pavers, Mixers—Gasoline Shovels, Cranes and Draglines

Determination of Concrete Specifications

(*Continued from page 276*)

mixed aggregate might be made up of relatively more stone and less sand but in that case it should give a strength greater than 2200 pounds per square inch as the resulting fineness modulus will exceed 5.25.

Experiment will determine how many volumes of sand and pebbles mixed in the ratio of 1:1-⅛ will give a dry mixed aggregate of 5.8 cu. ft. for each sack of cement Further experiment will determine what volume of loose damp material is equivalent to the required dry, rammed aggregate and the measuring boxes can be built to give these volumes. There is always an approximation when fine aggregate is measured loose, as the looseness and dampness may vary. A New York contractor has developed an inundation apparatus by means of which the sand is measured under water, rapidly and accurately, the water and sand both forming part of the mix. This discussion doubtless gives the impression that the proportioning of concrete is a difficult and long drawn out matter; one which cannot be easily performed by the average contractor. It should be remembered, however, that the full procedure is only performed once at the start of the job. If the aggregates continue to come from the same sources, it is only necessary to make daily checks of the grading and moisture content, with the accompanying slight modifications of proportions of aggregate or water. While the water-cement ratio should be held constant, it is quite desirable on a big job to occasionally take test specimens from the concrete to make sure the strength is actually realized and, incidentally, not too greatly exceeded.

A strength requirement as the standard of the concrete mix permits the contractor to use poorly graded materials if he wishes with the corresponding increase in the richness of the mix. He may also, if he cares, take the trouble to select and grade a mixed aggregate of great excellence which will require a minimum of cement to give the strength. The procedure described has been evolved so that such a man may prosper.

There have been three generations in the history of the manufacture of concrete. In the early days when natural cements were still used and concrete was employed chiefly in footings, retaining walls, piers, etc., the engineer made a mix and trusted to Providence it would hold the load. In fact, after a night or two of worry he would come down to the mixer and add a sack of cement to the mix to assist Providence.

This man's son was required, in his day, to make a definite mix, 1:2:4, or 1:2½:5 or whatnot, with no variation for the materials used. Naturally, he chose the cheapest materials the inspector would accept without regard to their strength-giving properties. Neither he nor the engineer on the job passed sleepless nights but at times they might well have done so.

The grandson, a building contractor, is just beginning business. His hands are untied as his father's never were. He can use any material he wishes, make any mix he wishes, providing he delivers the required strength and wearing qualities. For the first time there is an incentive for the contractor to watch his mix and there is a reward for the man who selects clean, well-graded material carefully proportioned.

VENUS PENCILS

The Largest Selling Quality Pencils in the World

The Lead is absolutely free from grit or even the slightest coarseness; remarkably smooth and long-lasting.

Each of the 17 degrees are uniform with every pencil of that degree—always.

The wood is specially selected cedar, of the best quality obtainable.

Their perfection makes them *economical* as they can be used down to the last inch.

The distinctive *watermark finish* avoids substitution—known and recognized throughout the world.

UNIQUE THIN LEAD COLORED PENCILS
Trade Mark Registered

Make fine lines for figuring, checking, sketching, blueprints, etc.

Blue	Purple	Pink
Red	Brown	Lt. Blue
Green	Orange	Lt. Green
White	Yellow	Maroon

$1.00 per doz.

17 Black Degrees
3 Copying

For bold heavy lines 6B-5B-4B-3B
For writing, sketching 2B-B-HB-F-H
For clean fine lines . . 2H-3H-4H-5H-6H
For delicate, thin lines 7H-8H-9H

Plain Ends—per doz. $1.00
Rubber " —per doz. $1.20

At Stationers and Stores throughout the World

American Lead Pencil Co.
218 Fifth Av., Dept. M1, New York

Harcourt Equipment for Chemistry

K KNOTT

L. E. KNOTT APPARATUS COMPANY
CAMBRIDGE MASSACHUSETTS

SINCE 1895

KEYSTONE COPPER STEEL

Steel Sheets that Resist Rust!

The destructive enemy of sheet metal is *rust*. It is successfully combated by the use of protective coatings, or by scientific alloying to resist corrosion. Well made steel alloyed with Copper gives maximum endurance. Insist upon

KEYSTONE
Rust-Resisting Copper Steel
Sheets

Black and Galvanized

Keystone Copper Steel gives superior service for roofing, siding, gutters, spouting, culverts, flumes, tanks, and all uses to which sheet metal is adapted—above or below the ground. Our booklet *Facts* tells you why. We manufacture American Bessemer, American Open Hearth, and Keystone Copper Steel Sheets and Tin Plates.

Black Sheets for all purposes
Keystone Copper Steel Sheets
Apollo Best Bloom Galvanized Sheets
Apollo-Keystone Galvanized Sheets
Culvert, Flume, and Tank Stock
Corrugated Sheets
Formed Roofing and Siding Products
Automobile Sheets—all grades
Electrical Sheets, Special Sheets
Deep Drawing and Stamping Stock
Tin and Terne Plates, Black Plate, Etc.

Our Sheet and Tin Mill Products represent the highest standards of quality, and are particularly suited to the requirements of the mining, engineering, and general construction fields. Sold by leading metal merchants. Write nearest District Office.

American Sheet and Tin Plate Company
General Offices: Frick Building, Pittsburgh, Pa.
District Sales Offices
Chicago Cincinnati Denver Detroit New Orleans New York Philadelphia Pittsburgh St. Louis
Pacific Coast Representatives: United States Steel Products Co., San Francisco Los Angeles Portland Seattle
Export Representatives: United States Steel Products Co., New York City

Most touchdowns are teamwork

The crowd cheers the backfield star who sprints across the line, forgetting for the moment the lineman who took out the last opposing tackler. Yet most touchdowns result from teamwork, the coordinated efforts of a group of men each fulfilling his own special function.

Teamwork wins in manufacturing as well as in other forms of activity. Winning for Jenkins Valves an "All-American" reputation among valve users is the result of teamwork—teamwork between designing engineers, metallurgists and department heads in every stage of manufacture.

Resulting from this teamwork are valves built for the maximum service not merely the average. It is characteristic of Jenkins standards that each valve must pass a wide margin test before it leaves the factory.

There are genuine Jenkins Valves in bronze and in iron, for practically every power plant, plumbing, heating and fire protection requirement.

Fig. 325
Screwed, Jenkins Standard Iron Body Gate Valve

Send for a booklet descriptive of Jenkins Valves for any type of building in which you may be interested.

JENKINS BROS.
80 White Street.....New York, N. Y.
524 Atlantic Avenue.....Boston, Mass.
133 No. Seventh Street...Philadelphia, Pa.
646 Washington Boulevard....Chicago, Ill.

JENKINS BROS., LIMITED
Montreal, Canada London, England

Always marked with the "Diamond"
Jenkins Valves
SINCE 1864

Industrial Illumination Research

(*Continued from page 274*)

ers. A new foreman or shop boss may cause a large change in efficiency.

Outside interests and activities contribute their share in the general effect. The drop in production around holidays is known to every factory man. Then there is the vital effect of physical condition. This subject needs no enlargement — we all have first hand information on the relation of our general condition with what we accomplish.

In conclusion it is desired to emphasize the following statements. Any investigation attempting to evaluate definitely the effect of illumination or some such influence, must take the greatest of pains to control or eliminate all factors but the one being studied. Many of them can be controlled or eliminated, but the one great stumbling block remaining is the problem of the psychology of the human individual.

This résumé of a series of tests has merely touched the high spots. Detail was impossible in such a short article. The complete and final report of the whole investigation will be published by the division of engineering and research of the National Research Council in 1928, associating numerous tests in factories, much laboratory work and study by notable psychologists carried on at the instance of the committee which has secured a volume of information that it is believed will prove serviceable to the industries in this important factor of artificial illumination.

A Streamline Rudder is the latest application of the principles learned from aerodynamics. Experiments have shown that a wing fairly thick and well-rounded in front, tapering to an edge in the rear, gives the least resistance in proportion to the lifting power. Applied to the rudder of a ship, this principle means the least resistance in proportion to the steering effect.

The streamline construction is maintained at all angles by dividing the rudder into two parts. The fore part is built as a fixed guide about a rudder post, and consists of about one-third the total length. The after part, which does the actual turning, fits into the fixed fore part.

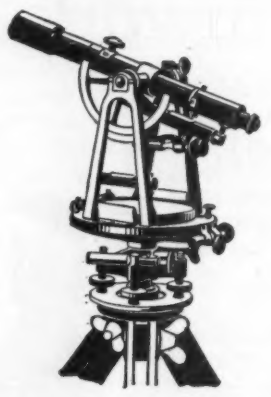
It has been found that a rudder of this type is economical and will require from one-half to seven-tenths of the power required to operate the rudders commonly used. In addition, the vibration so often felt in the stern of vessels is done away with. The German and Dutch steamship companies were the first to take advantage of this improvement and equip their vessels with this type of rudder, but some of the larger American companies are now interested and are installing similar equipment on American ships.

Agriculture

(*Continued from page 264*)

on the regular homestead farm in the semi-arid regions. A two thousand acre farm is the minimum, and with modern machinery such a farm can be operated by a few skilled men. The same is almost true of one hundred sixty acres of corn land in any of our older states. All quarter section farms should be consolidated into sections of land or into some other unit of economical operation, such as eighty ton furnaces, thousand barrel cement plants, thousand barrel flour mills, etc. All other industries have, by experience and records, proven economical operating units, but the farming industry to date has not even given this a thought. This is a point which could be well worked on by the Department of Agriculture.

There are, admittedly, many obstacles in farming, such as weather hazards, insect pests and variable markets, but the biggest obstacle the farmer has to overcome today is the universal belief expressed by our bankers, railway presidents, industrial heads, politicians, economists, and even by our good Secretary of Agriculture, that farming cannot succeed. I predict that the time will come within twenty years when farming will be industrialized, when it will have the prestige and dignity to which it is entitled and when it will attract and hold the country boy with brains, who is now in town directing ninety per cent of our industrial development. This success will bring independence to the farmer and will hasten orderly marketing. It will make it possible for him to market his grain as and when he thinks fit without doing it under the direction of some mortgagor. Our coöperative marketing associations have failed so far primarily because only a small per cent have ever signed and seventy-five per cent of the wheat was mortgaged. The independent farmers have not joined. When fifty-five per cent of the farmers sign up they will be a real factor. The greatest work, however, will be accomplished by the agricultural engineer.



Engineers and contractors know that BUFF performance is accurate and sure — without having to adjust the transit once.

We will, on request, mail a 4-inch high Bas-relief of Nickel-silver — being an exact likeness of the "Engineer's Best Friend" — "the Buff Transit."

Write for the BUFF Catalog No. 20M.

BUFF & BUFF MANUFACTURING CO.

Jamaica Plain, Mass.

BUFF

TRADE MARK TRADE MARK

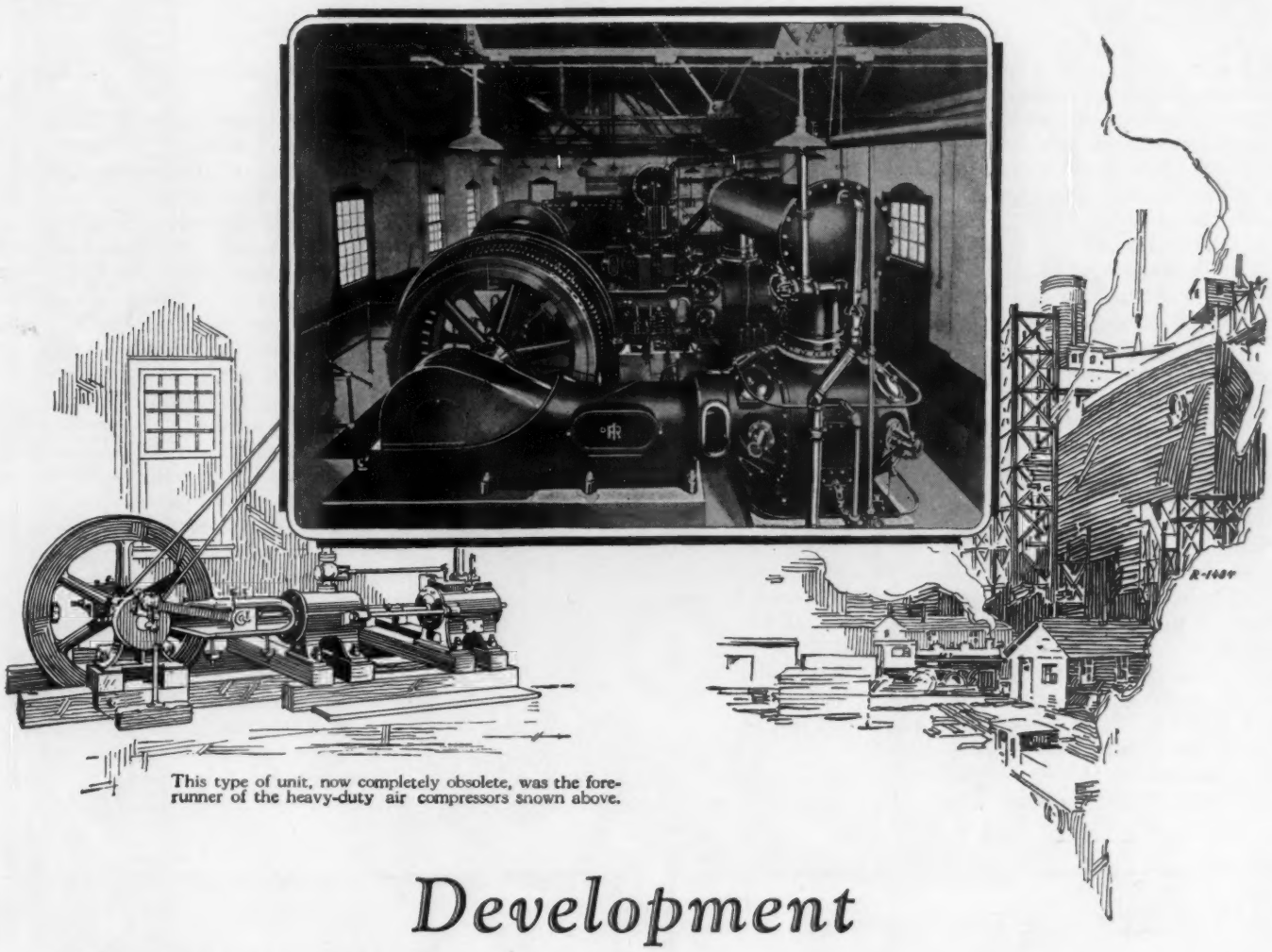
SAMSON SPOT SASH CORD

Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.

CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS : : **88 Broad Street, Boston 9, Mass.**



This type of unit, now completely obsolete, was the forerunner of the heavy-duty air compressors shown above.

Development

COMPRESSED air is now one of the three great power-transmitting media. Because of this, the present-day compressor is necessarily a model of smoothness and efficiency.

The big compressors shown above contrast sharply with their predecessors of thirty years ago. The earlier machines were cumbersome, unwieldy units of low capacity and even lower efficiency. But the modern types, developed with all the care of skillful engineers, are made for every industry and every type of work; they are, in fact, no less essential than the numerous mechanical devices now powered by electricity and steam.

Many I-R Compressors are equipped with the patented five-step Clearance Control, by means of which regulation is obtained in five successive stages. This method of regulation (viz., full, ¾, ½, ¼, and no load) means that the power reduction is practically in direct proportion to the reduction in load.

Ingersoll-Rand Compressors are built in more than 1,000 sizes and types, their capacities ranging from 7 to over 10,000 cu. ft. per minute. Like the other I-R products, they are universally known, and today you will find them in every country of the civilized world.

INGERSOLL-RAND COMPANY
11 Broadway ~ New York City
Offices in principal cities the world over

Ingersoll-Rand

Turbo-Generators

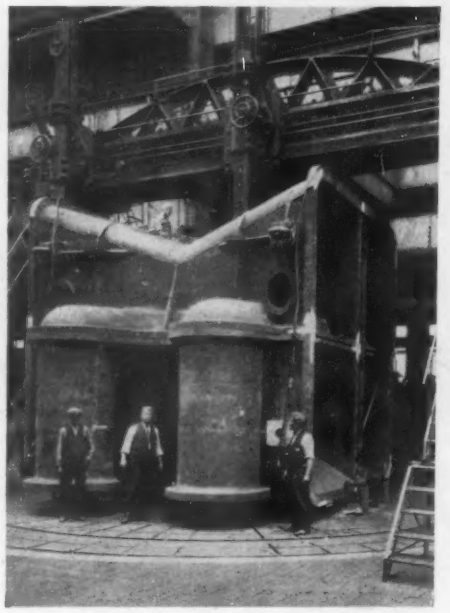
(*Continued from page 261*)

The unit consists of a single flow high pressure element and a double flow low pressure element which will be arranged to exhaust into four vertical condensers. The main generators are wound for 16,500 volts (which is the highest voltage used to date) and are rated 90,000 kw 90 per cent power factor and operate at 1500 rpm — 50 cycles. The set is also equipped with a 4,000 kw service generator.

The main generator is arranged for the possiible future use of hydrogen as a cooling medium.

The welded generator construction used with this machine reduces the total weight and size enough to enable this generator to be completely assembled and wound at the factory. At destination the outside shells and feet will be assembled to the inner frame, thereby completing the generator.

There is now being installed in the South Meadow Station of the Hartford Electric Light Company a 10,000 kw mercury turbine which will be the largest of its kind. The experimental mercury boiler and turbine installed in this station for sometime operated so successfully that the installation of several standardized commercial equipments of about 10,000 kw capacity can be expected in the not far distant future.



EXHAUST SHELL OF THE TANDEM COMPOUND TURBINE

The capacity of this turbine is 94,000 kw. The shell is in position on the boring mill

The 1200-pound turbine generating 10,000 kw will soon be running in the Edgar Station of the Edison Electric Illuminating Company of Boston. A 7,000 kw 1200-pound turbine is operating successfully in the Lakeside Station of the Milwaukee Electric Light Company. This operating company made the following statement in the 1927 report of the Prime Movers Committee of the N. E. L. A.

"Since the turbine water rate is known with accuracy it is expected that the high pressure installation will ultimately be 15 per cent more efficient than the 300-pound equipment."

In conclusion it seems reasonable to expect that in the future steam turbine units of still larger capacity will be built if and when the Central Station Industry demands them. Units to operate at higher temperatures and pressures will also be developed as the economic need arises. Central stations have realized this, for in most all cases, floor space has been provided that will ultimately be taken up by future units.

Two M. I. T. Publications

De DONDER—
The Mathematical Theory of Relativity
Price $2.75

MAX BORN—
Problems of Atomic Dynamics
Price $3.50

A book of Interest to All Tech Men

We still have a limited number of
the four dollar edition of James Phinney Munroe's

Life of
FRANCIS AMASA WALKER
President of Massachusetts Institute of Technology
1881-1897

These will be sold for one dollar a copy
postpaid to any address in the United States
until the supply is exhausted

Mail orders will be filled in rotation as received

Technology Branch
HARVARD CO-OPERATIVE SOCIETY

THE TECH ENGINEERING NEWS

Is the monthly Professional Journal of the Undergraduates at the Massachusetts Institute of Technology. It publishes:

Articles on Scientific Investigations at the Institute

and

Articles of General Scientific and Engineering Interest by Leading Authorities from All Over the World

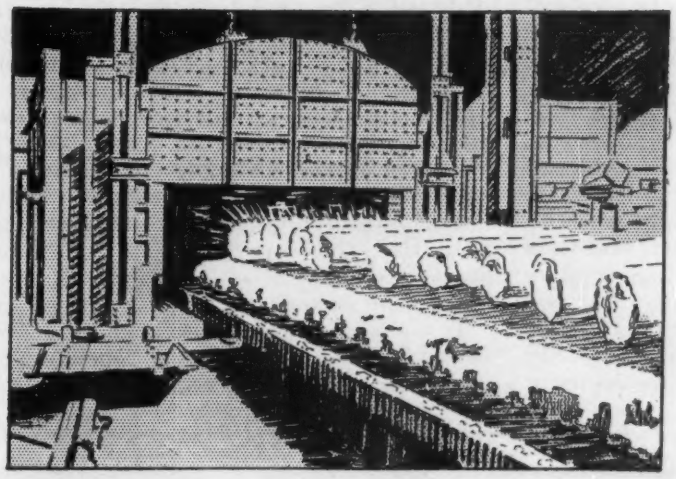
We are desirous of having You on our Mailing List. Subscription Price is $1.50 for eight issues. Send this Coupon with Your Check.

Name .....

Address .....

.....

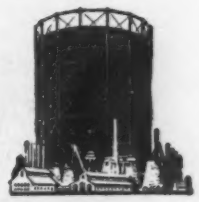
No job too great *for* Gas !



TWENTY tons of white hot steel are being rolled out of this huge GAS FURNACE on a steel flat car, which forms the hearth.

The large pieces of steel on the car are locomotive axles which have been through an annealing process in this gas-fired furnace, an operation that precludes all likelihood of axles breaking.

Industrial gas maintains in this furnace a temperature of 1600 degrees Fahrenheit.



Gas is the most "Flexible" of all fuels. It can be used in a jeweler's tiny torch, or for huge operations, such as pictured above. It is also "Flexible" in the sense that its volume and intensity can be raised or lowered, instantly, at the turn of a valve. It gives a concentrated heat wherever needed without involving bulk, waste energy or waste material.

Gas is obviously the Industrial Fuel of the day. Write to your gas company for facts concerning the use of gas in YOUR industry, or to

American Gas Association
420 Lexington Avenue, New York City

YOU CAN DO IT BETTER WITH GAS

Departmental Notes

(*Continued from page 269*)

of Applied Chemistry to head its research and development program. Prof. L. W. Parsons, who had been assistant director under Wilson, left at the same time to become director of research and development for the Tidewater Oil Company. Professor Haslam succeeded Wilson here at the Institute, with Prof. W. G. Whitman as assistant director. Professor Wilson was so successful in his new work that the oil companies chose him as the expert in their defense of the government suit, the substantial purpose of which was to annul the defending companies' patents covering the developments of the last fifteen years in the production of gasoline by the cracking process. The demands made upon his time by this work, plus the death of his chief assistant, R. G. Hunneman, X-A, '23, led Mr. Wilson to induce Professor Whitman to join the Standard Oil staff. R. P. Russell, co-author with Professor Haslam of "Fuels and their Combustion," took Whitman's place in the Research Laboratory, but two years later joined the Standard Oil Company of Louisiana in a capacity similar to that of his predecessors at the Institute. Professor Haslam, who now goes with the Standard Oil Company of New Jersey, makes a total of five out of six directors and assistant directors of the Research Laboratory who have gone into the oil industry in responsible technical positions in the last five years. In addition a large number of graduates of Courses X and X-A and younger members of the department staff have entered the same industry.

Mr. E. L. Chapell, who recently concluded his work with the department, has been doing research work for the National Tube Co. of Pittsburgh. A full report of his work with the department, both in research and in the practical application of the acid-inhibitor process for cleaning water pipes on a large building in New York, was given before the spring meeting of the American Society of Chemical Engineers.

In this connection, it is interesting to note that the department gives no specialized training or instruction in oil refining as such.

In common with the other engineering departments of the Institute, its policy is not to teach the details of any specific industry, but to ground men in the fundamental sciences and to drill them in the technique of applying those sciences to the solution of the type of problems that are encountered in its industrial field. Thus, one of the most important operations of the oil industry is distillation. However, the training which the department offers in distillation is broad and fundamental enough to be applicable not only to petroleum and its products but to all those other industries which require effective separation of mixtures of liquids of varying volatility. The details of the industry are learned most readily and effectively in the industry itself.

It is the function of the Institute to give to the student not these details, but an adequate grasp of the fundamentals of science and engineering, which will make it possible for him not only to appreciate and interpret the operations of the industry as conducted at present, but to visualize its potentialities for the future and because of that vision be able to furnish the leadership necessary for its development.

WIRE automobile and airplane wires, electrical wires, submarine cables, bridge-building cables, wire rope, telegraph and telephone wire, radio wire, round wire, welding wire, flat wire, star-shaped and all different kinds of shapes of wire, sheet wire, piano wire, pipe organ wire, wire hoops, barbed wire, woven wire fences, wire gates, wire fence posts, trolley wire and rail bonds, poultry netting, wire springs, concrete reinforcing wire mesh, nails, staples, tacks, spikes, bale ties, steel wire strips, wire-rope aerial tramways. Illustrated story of how steel and wire is made, also illustrated books describing uses of all the above wires sent free.

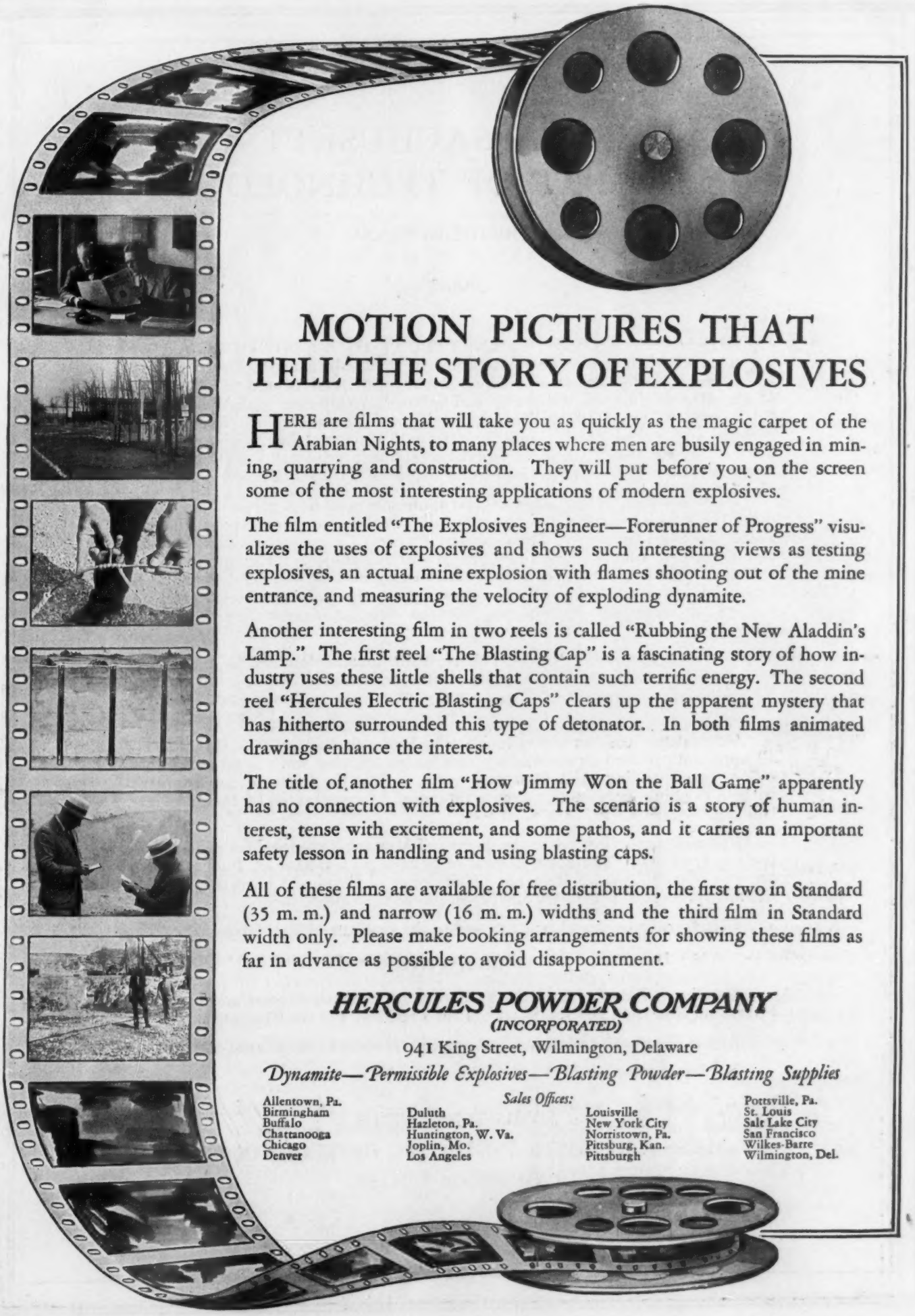
AMERICAN STEEL & WIRE COMPANY

Sales Offices

Chicago New York Boston Cleveland Worcester Philadelphia Pittsburgh Buffalo Detroit Cincinnati Baltimore Wilkes-Barre St. Louis Kansas City St. Paul Oklahoma City Birmingham Memphis Dallas Atlanta Denver Salt Lake City

Export Representative: U. S. Steel Products Co., New York

Pacific Coast Representative: U. S. Steel Products Company, San Francisco, Los Angeles, Portland, Seattle



MOTION PICTURES THAT TELL THE STORY OF EXPLOSIVES

HERE are films that will take you as quickly as the magic carpet of the Arabian Nights, to many places where men are busily engaged in mining, quarrying and construction. They will put before you on the screen some of the most interesting applications of modern explosives.

The film entitled "The Explosives Engineer—Forerunner of Progress" visualizes the uses of explosives and shows such interesting views as testing explosives, an actual mine explosion with flames shooting out of the mine entrance, and measuring the velocity of exploding dynamite.

Another interesting film in two reels is called "Rubbing the New Aladdin's Lamp." The first reel "The Blasting Cap" is a fascinating story of how industry uses these little shells that contain such terrific energy. The second reel "Hercules Electric Blasting Caps" clears up the apparent mystery that has hitherto surrounded this type of detonator. In both films animated drawings enhance the interest.

The title of another film "How Jimmy Won the Ball Game" apparently has no connection with explosives. The scenario is a story of human interest, tense with excitement, and some pathos, and it carries an important safety lesson in handling and using blasting caps.

All of these films are available for free distribution, the first two in Standard (35 m. m.) and narrow (16 m. m.) widths and the third film in Standard width only. Please make booking arrangements for showing these films as far in advance as possible to avoid disappointment.

HERCULES POWDER COMPANY
(INCORPORATED)
941 King Street, Wilmington, Delaware

Dynamite—Permissible Explosives—Blasting Powder—Blasting Supplies

Sales Offices:

Allentown, Pa.
Birmingham
Buffalo
Chattanooga
Chicago
Denver
Duluth
Hazleton, Pa.
Huntington, W. Va.
Joplin, Mo.
Los Angeles
Louisville
New York City
Norristown, Pa.
Pittsburg, Kan.
Pittsburgh
Pottsville, Pa.
St. Louis
Salt Lake City
San Francisco
Wilkes-Barre
Wilmington, Del.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers Courses, each of four years' duration, in Civil, Mechanical, Electrical and Aeronautical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy and Geology; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health and Sanitary and Municipal Engineering; Mathematics, Physics, General Science and General Engineering; and in Engineering Administration. These Courses lead to the degree of Bachelor of Science.

To be admitted to the first year class applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History and French or German and two units of elective subjects. Examinations are required in all subjects except Chemistry, History and the electives, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are also offered. Special Research Laboratories of Physical Chemistry, Organic Chemistry, Applied Chemistry and Science have been established.

Correspondence should be addressed to the Institute of Technology.

PUBLICATIONS

Catalogue: Bulletins of General Information, Summer Session, and Graduate Study and Research; and the Report of the President and the Treasurer.

Any of the above named publications will be mailed free on application.

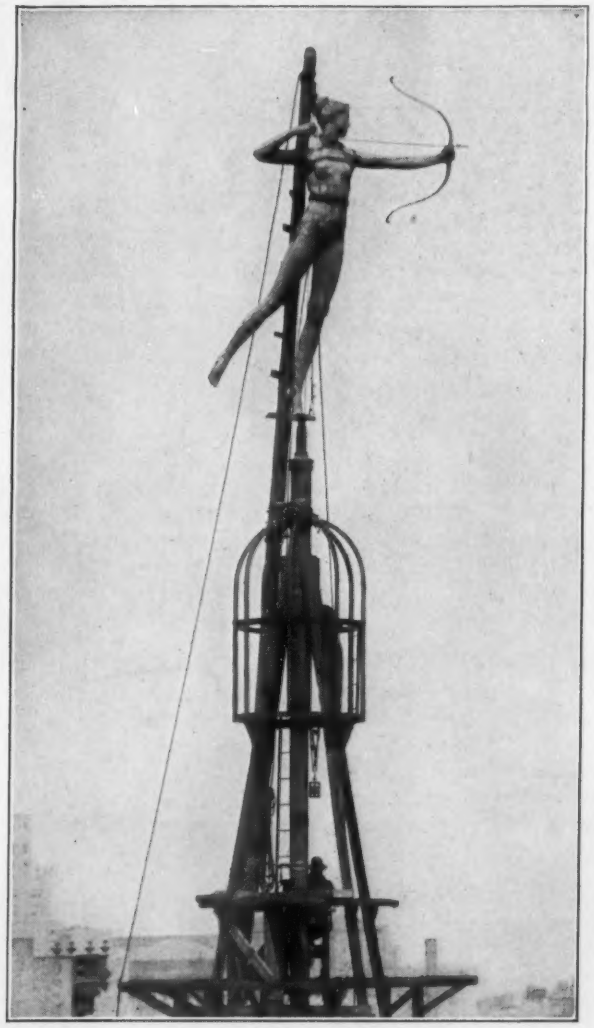
For information, address

ADMISSIONS OFFICE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE A, MASS.

THE TECHNOLOGY PRESS, CAMBRIDGE, MASS.



DIANA—On Her Way to New York University

FORMER college generations remember the old Madison Square Garden (the creation of the late Stanford White) which housed Moody and Sankey Revivals, Barnum Circus, Six-Day Bicycle Races, Tex Rickard's Prize Fights, Horse Shows, Democratic Conventions, etc. Gracefully and serenely poised on top, the St. Gaudens statue of Diana was for years an outstanding figure in the New York skyline.

Diana is experiencing discomforts of detours but is on her way to an appropriate spot on the New York University Campus. Illustration shows Diana about to step off on her way to college—in splendid physical condition and destined to rank high among the college immortals.

The old Otis Elevator that bore many famous people to the White Studio in the Tower has been junked. The New York Life Insurance Company is erecting a huge office building on the site of Madison Square Garden, as shown above.

The elevator equipment of the new building for the New York Life Insurance Company, Cass Gilbert, Architect, consists of 33 Otis Automatic Signal Control Elevators, operating at high speed, and equipped with the Micro-Drive or self-leveling feature; in addition to some few smaller and less important machines. Signal Control is automatic and the elevators are operated by pressure of buttons in the car or on the floors, all stopping and starting of the car being done automatically and in response to the calls registered on the controller by the pressing of such buttons.

OTIS ELEVATOR COMPANY

Offices in All Principal Cities of the World

How will your office look?

Not like this, of course

Yet you will find in it a dozen jobs that can be done more quickly and effectively by electricity—and done so quietly as to be practically unnoticed. In fact, electricity has completely revolutionized many office methods.

YOUR FATHER probably will recall the days of high stools, eyeshades, and evenings overtime.

. . .

But visit a modern office! A thousand letters to go out by four o'clock. A new price list to all customers in to-night's mail, without fail. Enter electricity. Two or three people turn switches, and the finished letters come out of an ingenious machine. Another motion and they are sealed and stamped. Only electricity could get that job done.

. . .

Here's a statistical job. The reports are in; thousands of figures to analyze. Looks like overtime for fifty clerks. "Certainly not," answers electricity, as a button starts the motor-driven sorters and tabulators. Key cards are punched with lightning fingers. Electric sorters devour 24,000 cards an hour. Tabulators add quantities and amounts in jig time, and print the totals.

. . .

Go to almost any bank today. Hand in your account book. Click, click, click, goes the electric book-keeping machine and back comes the book to you. Five operations performed in that brief moment. Everybody saves time, —you, the clerk, the bank,—when electricity is the book-keeper.

. . .

In the office of to-morrow you will find " electrical fingers" doing more work than even to-day.

TO-DAY in a modern office you will find these electrical aids:

Addressing Machines; Dictating Machines; Adding Machines; Multigraphs; Check-writers; Calculating Machines; Cash Registers; Interior Telephones; Card Recorders; Card Sorters; Time Recorders; Accounting Machines; Time Stamps; Clocks; Mailing Machines; Typewriters; Fans; MAZDA Lamps, and many other electric devices.

This familiar mark appears on many electrical products, including motors that drive time- and labor-saving office machines.

210-62DH

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK